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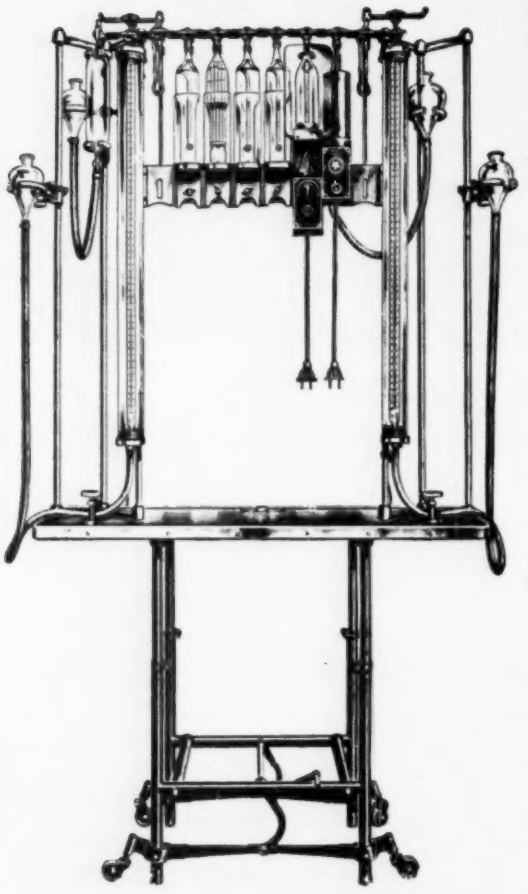

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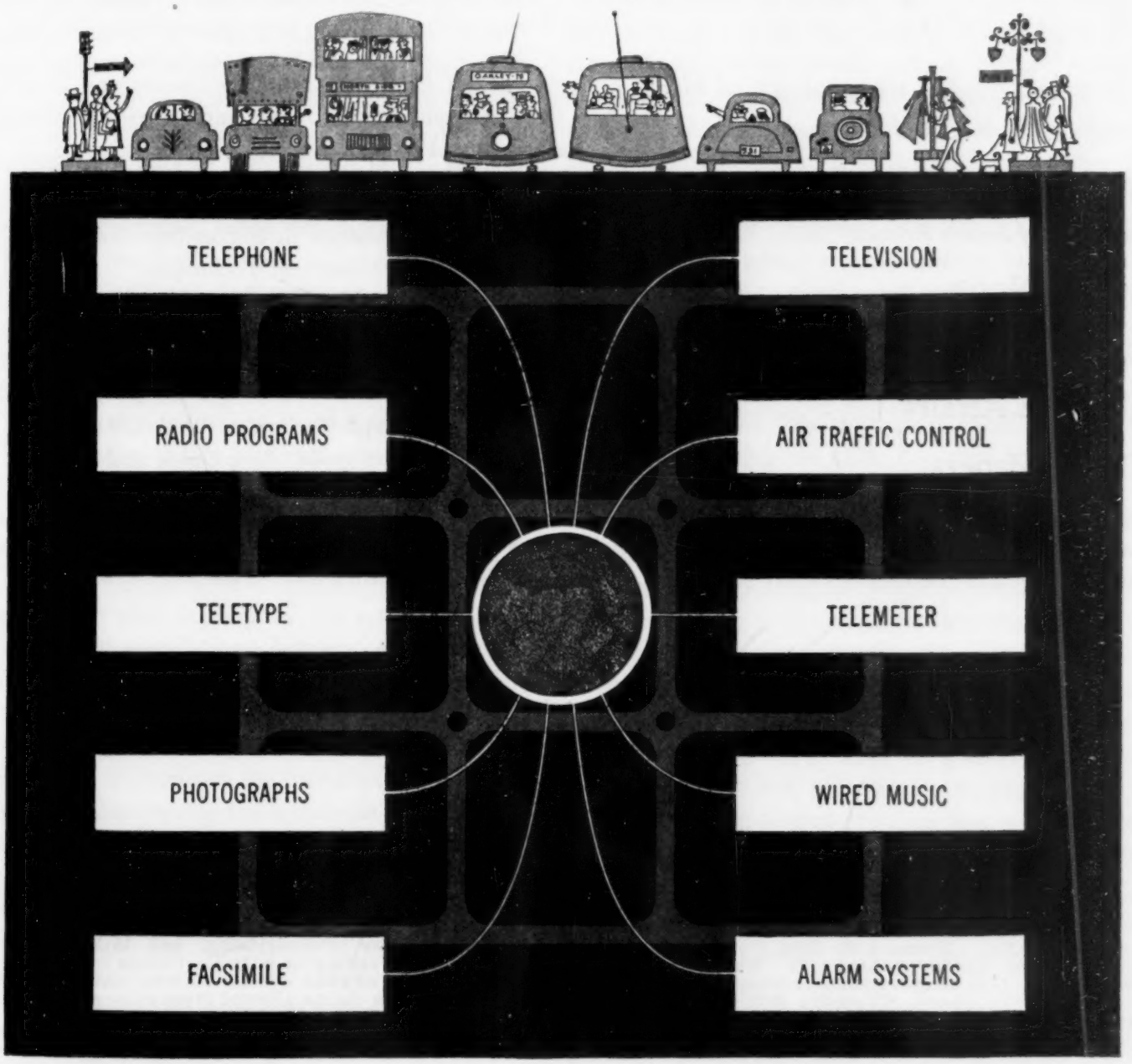


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# The Developmental Physiology of Seed Plants

W. F. Loehwing

*State University of Iowa*

THE COMPREHENSIVE INVESTIGATIONS of Georg Klebs during the early part of the present century mark the beginning of a persistent and increasing interest in the processes underlying the developmental cycle in the higher plants. After 1920, studies of physiological ontogeny developed rapidly, due to the classical work of Went on growth substances and the discovery of photoperiodism by Garner and Allard. Interest in developmental physiology was further heightened by publication of Lysenko's researches on vernalization and his provocative theory of phasic development in plants. The decade following these fundamental discoveries has proven to be one of the most important epochs in the entire history of plant physiology. The work of these men was important not only to pure science but to agriculture. It opened a new era, provided highly effective techniques, and permitted many practical applications. Every phase of plant science has felt the invigorating impact of these brilliant discoveries and of the more recent researches which they directly stimulated. Though information on developmental physiology has accumulated rapidly in recent years, the absence as yet of a thorough conspectus on the subject is evidently attributable to the diversified and dispersed character of the data rather than to paucity of knowledge on the subject.

## The Problems of Physiological Ontogeny

A preliminary step in the study of ontogeny is the establishment of correlations between environmental factors such as temperature, light, and nutrition and the plant's developmental and structural responses. Once such correlations of plant response to environment have been determined, the investigator confronts the problem of discovering the metabolic and nutritive processes within the organism by which its response is directly implemented. One of the useful concepts emerging from studies of vernalization and photoperiodism has been the distinction between formative alterations, primarily of a quantitative sort, and the definitely developmental responses reflecting profound qualitative modifications in function, which often are of an irreversible nature. Thus, vegetative growth may be able to continue indefinitely when there is no marked modification of metabolism, whereas developmental changes presumably betoken qualitative transitions both in form and function, bringing the plant closer to completion of its life cycle.

At one extreme we have the immediate response reaction in which the effect is coincident with, and proportional to, duration and intensity of the stimulus as involved primarily in the enlargement of vegetative organs. In this case a given metabolic and structural state can be sustained for long periods by maintenance of a given external stimulus, but growth in its quantitative aspects can be immediately altered by modification of the stimulus, usually without pronounced aftereffect or influence upon development proper.

At the other extreme are the developmental or so-called induced responses showing marked aftereffect, as typified by the flowering stimulus of the photoperiod. Obvious structural response to a specific light period in this case normally occurs weeks or sometimes months after application of a reproductive photoperiod, and its expression may become especially striking when the external conditions have altered in the interim after induction. The effects of a given photoperiod upon flowering are essentially irreversible in the affected organs after exposure to the minimal period of induction. Vernalization of partially imbibed seeds or of young seedlings at low temperature produces similar aftereffects. Even immature embryos still attached to the parent sporophyte may become responsive to temperature induction surprisingly soon after zygotic cleavage, and conditions existing during development of the seed or in very young seedlings may influence the subsequent ontogeny as much as the environment to which the plant is exposed for most of its later life. Consequently, any environmental condition existing at the time that a structural response becomes clearly evident may not necessarily be its actual causative factor. This is particularly true of flower formation, because the inception of flower initials under stimulus of the photoperiod commonly occurs surprisingly early in growth cycle of many herbaceous annuals—often within a few weeks after germination. Such contrasts in physiological induction during early life frequently underlie developmental differences observed in plants subsequently maturing in comparable environments. It is also necessary to consider that response to a fixed environmental

Address by the vice-president and chairman of the Section on Botanical Sciences (G), AAAS, delivered December 27, 1947, in Chicago, Illinois.

stimulus often varies with the stage of development of the organ to which it is applied. A case in point is the variation in photoperiodic response of a leaf with age. Thus far, only a few dependable physicochemical tests have been discovered which can be used as criteria of the stage of physiological development or as indices of the plant's probable ultimate response to a given stimulus.

The photoperiod and low temperatures also influence the number and character of vegetative organs such as leaves, bulbs, tubers, and fleshy roots, but the response does not involve induction or aftereffect as in the case of flower inception. Recent data suggest that fruit formation, as opposed to flower differentiation, may also be a photoperiodic response, but often with a distinctly different optimal light period than for flower development in the same plant. Such complex responses to external environment make it difficult to correlate them with the metabolism of the plant.

In addition to the foregoing complexities involved in developmental studies are those resulting from the configuration of the higher plants. Unlike the animal which commonly matures as an entity, the many separate apical and lateral meristems of typical plants give rise to a succession of new organs in a progressive sequence of time. The various parts of a well-established plant may thus display simultaneously the entire range of development from youth to senescence. Differences in stage of development are not, however, entirely a matter of age alone, as tissues originating from the younger portions of the growth axis are often in more advanced stages of development, due to the physiological condition of the meristems from which younger organs originate. Consequently, neither comparable size or age of various organs nor even that of plants as a whole is an entirely reliable criterion of developmental similarity.

Ontogenetic differences among various organs of a plant also arise in part from the fact that the individual plant commonly alters its own environment during growth in such a way that structures appearing in chronological sequence along the main axes constitute an ecological succession with concomitant differences in metabolism and development of contiguous parts. Annual species with an axial growth habit, for example, often exhibit an acropetal progression from distinct mesomorphy of lower leaves to comparative xeromorphy of mature upper leaves on the same stem.

Correlated with such structural and developmental differences between basal and terminal leaves on a single shoot is a related series of physiological gradients. Positive gradients, characterized by steady increments in the progression from lower to upper leaves and stems, are commonly found in the values for osmotic pressure of cell sap, total nitrogen, and certain enzymes and hormones. Negative gradients, diminishing from base to tip of shoot, characterize the concentration of hydrolysable polysaccharides, moisture content, organic acids, calcium, sulfur, and magnesium. Certain types of gradients are also found in roots.

Minimal levels of nutrition essential to normal metabolism of comparable structures frequently are a function of their location on the plant and of prevailing environmental conditions. Thus, upper leaves often begin to exhibit deficiency symptoms for certain mineral elements at concentrations much greater than those at which they appear in lower leaves of the same plant. The inference in this case is that the salt requirement of younger organs is greater than that of the older structures. Similarly, when the photoperiod is shortened, as is often done to induce flowering, previously normal plants may begin to show marked evidence of mineral insufficiency, particularly with respect to the so-called minor elements.

The student of developmental physiology also encounters another phenomenon not yet generally recognized, namely, that the formative effect of a given nutrient element varies with the ontogenetic phase at which it is made available. While high nitrogen is known to induce a markedly mesomorphic type of foliage, it can in many species cause a distinctly xeromorphic habit and thick succulent leaves approximating those of the Crassulaceae. Such foliar xeromorphy frequently occurs in plants of the Solanaceae when nitrogen is made liberally available just prior to, or during, flower inception, but it does not occur in plants kept continuously on high nitrogen.

Considerations of the foregoing sort impose rather exacting details of experimental technique in tracing the nature and correct sequence of changes in nutrition during the growth cycle. Methods of sampling and expression of data become especially critical in studies of nutritional ontogeny. Frequent sequential analyses of highly localized samples, maintained throughout development as a continuous record in terms of absolute quantities per unit of tissue or per plant rather than as percentage composition, are indispensable to detection of qualitative alterations in metabolism and of quantitative shifts in distribution of materials. Only by means of data in terms of actual amounts is it possible to determine the metabolic efficiency of individual structures or of the plant as a whole at particular stages of development. A simple illustration in point is found in the mineral components of the plant. Though salts actually continue to increase in absolute amounts during most of the plant's life, their percentages normally decrease because of the more rapid accumulation of organic synthates. By

means of data in terms of percentages alone it is difficult, if not impossible, to determine the exact time and locus either of cessation in absolute increments or of the inception of actual depletion of nutrient components.

### The Vegetative Phase

In scanning the numerous studies of developmental physiology, it is surprising to find many similarities in fundamental processes despite the extreme diversity of plant types and environmental conditions involved. As might be expected, a preponderance of data exists concerning herbaceous annuals, and the most consistent portion of this information relates to plants grown under controlled environmental conditions. Comparable data for biennials and perennials, often of necessity grown under field conditions, are less exact, relatively incomplete, and hence more difficult to correlate. Because of this fact and for purposes of brevity, discussion is limited here to those aspects of developmental processes which seem common to a wide range of ordinary herbaceous annuals. Many investigators have maintained plant cultures at relatively constant nutrient levels throughout their experiments to avoid difficulties arising from undue luxury consumption of certain elements in early ontogeny and other fluctuations of salt supply during growth which occur when a single initial feeding is employed. Recent investigations have stressed the necessity of including root analyses—a practice which has led to the increasing use of artificial substrates rather than soil as a matter of convenience in recovering root systems for exact analysis.

In terms of absorption, the vegetative phase of many different species is marked by preferential absorption of nitrogen, the intake of which during the first few weeks is often sufficient not only to cover much of the plant's subsequent need for this element but to create an appreciable reserve of nitrate and amide nitrogen. During rapid expansion of the shoot, protein formation parallels both the rate of photosynthesis and the supply of sugars, correlations which suggest the dependence of protein formation upon the supply of soluble carbohydrates at this stage. It has been shown that all conditions, such as light, open stomata, and photosynthesis, which raise the internal oxygen tension favor protein formation in young plants. In the vegetative plant, photosynthesis as a source of carbohydrates and oxygen is closely related to reduction of nitrates and production of new tissues.

Potassium and phosphorus intake in early vegetative life is also rapid, and these elements, along with nitrogen, commonly accumulate in distal portions of the shoot. Absorption of calcium, magnesium, sulfur, and iron is relatively slow but persistent throughout ontogeny. These elements are also less rapidly translocated and tend to accumulate in the basal portion of plants. Leaves show preferential absorption of potassium, calcium, and magnesium. In several studies involving variations in salt supply, it has been noted that beneficial effects of soil amendments are correlated with increments in foliar area rather than with increased photosynthetic efficiency.

Determination of top-root ratios during ontogeny reveals certain rhythmic fluctuations. Though evident during the vegetative phase, such fluctuations later become more pronounced and indicate an inherent lack of coincidence between rates of root and shoot enlargement. A low supply of carbohydrates in roots is frequently correlated with slow root growth and diminished absorption of salts and water. Such responses indicate the importance of root respiration to absorption and growth of the plant as a whole and provide a striking illustration of the effect of the shoot on root activity. Ontogenetic studies reveal that within wide limits such fluctuations are not necessarily incompatible with development and that they are normal occurrences even under optimal or artificially stabilized growing conditions.

In the course of vegetative growth, the rate of carbohydrate accumulation eventually exceeds protein synthesis, and the production of new vegetative tissues then begins to decline. This transition in carbohydrate-nitrogen balance is coincident with changes in moisture content of tissues. Older leaves reach their maximal moisture content simultaneously with attainment of maximal area, while young leaves continue to gain in moisture content after their enlargement has ceased. Distal portions of the shoot also maintain their moisture content at the expense of older leaves. The shift in water balance of the shoot is in turn correlated with accentuation of xeromorphy in fully developed upper leaves—an observation which suggests that meristems from which such leaves arise are also undergoing change. Thus, the higher the level of leaf insertion, the lower its moisture content and the higher its unit rate of transpiration. Comparative foliar xeromorphy and rapid accumulation of carbohydrates distinguish this phase of growth from the earlier vegetative phase characterized by the predominance of protein synthesis and rapid salt absorption.

### The Flowering Phase

In determining the transition from vegetative growth to flowering, the physiologist prefers to regard the metabolic shifts which are antecedent to initiation of floral organs as the actual onset of sexual reproduction. It is necessary to distinguish between flower

inception, anthesis, and fruiting, because each of the structurally distinguishable stages such as microsporogenesis, megasporogenesis, anthesis, and syngamy is preceded by characteristic changes in metabolism and rate of growth. While there are important differences between plants of determinate (grasses) and indeterminate (many dicots) habits, a subsidence in rate of stem elongation can often be taken as an index to the onset of synapsis. This is a matter of experimental convenience due to the difficulty of obtaining direct evidence of the exact time of sporogenesis.

Metabolically, the inception of reproduction is marked by an increase in hydrolytic processes and a general mobilization of nutrient reserves. Protein and carbohydrate digestion is accelerated in basal leaves, which show considerable loss of moisture in favor of upper leaves. Taken in their entirety, the transitional changes involve a subsidence of organic syntheses and a positive rise in certain catabolic processes. The plant's nutrient gains seem temporarily incapable of completely covering its catabolic losses.

The sequence of changes in moisture content have been well determined, probably because of the ease of performing this particular measurement. Though water absorption may rise during early stages of reproduction, transpiration evidently overbalances supply, judging from the diminishing moisture content of the shoot. Conditions in basal leaves at this time are particularly puzzling, as they lose moisture and nitrogen despite the fact that the osmotic pressure of their tissue fluids increases. This seems to be attributable to loss of hydrophilic colloids by hydrolysis, as has been particularly well worked out for several different types of plants.

The altered moisture balance of the shoot is correlated with diminished translocation of carbohydrates to the roots. A temporary subsidence in water and salt absorption then occurs. Only upon subsequent replenishment of root carbohydrates is the preceding rate of salt and water absorption restored.

Concurrent with the high rates of respiration in flowers during anthesis, there is a drop in the rate of foliar respiration, in photosynthesis, and in protein formation. The decline in protein production parallels both the drop in foliar respiration and photosynthesis. There is evidence that the resulting reduction in internal oxygen is a major factor in the depression of respiration and hence in the subsidence of protein synthesis. Various carboxylic acids accumulate in plants during reproduction, but their formation can be greatly reduced by prevention of flowering, as is regularly done in the process of topping tobacco. Unfortunately, there is as yet no consensus on the origin, role, or fate of the organic acids which appear during the flowering phase. There is considerable evidence, however, that they accumulate rapidly when cation absorption exceeds anion intake.

It has long been known that developing flowers are foci for accumulation of nutrients, but we do not as yet have decisive evidence concerning the factors which bring this about. The early phases of the migration of food to young flowers have been especially difficult to explain because the obvious enzymatic and hormonal changes in floral organs occur after, rather than before, fertilization. During anthesis, food reserves previously stored in perianth segments are translocated to sex organs with surprising rapidity. The effects of this change are, however, local and restricted chiefly to the flower itself, compared to the systemic alteration of metabolism following syngamy.

Studies of developmental physiology in monoecious and dioecious species have been helpful in clarifying complicated conditions prevailing in the more common hermaphroditic species in which staminate and pistillate processes are superimposed or follow so rapidly as to make their fundamental differences difficult to determine. Monoecious species are experimentally convenient in studies of the physiology of sex. A single plant may readily be rendered unisexual by exfloration, thus providing the possibility of checking differences between staminate and pistillate processes. In dioecious species or in monoecious forms rendered unisexual, the pistillate condition is characterized by lower oxidation potential of tissue fluids than that in staminate plants. Fats and the amino acids, alanine, lysine, and arginine, are more abundant in pistillate plants, while histidine and proline occur in larger amounts in staminate plants. A reduction in oxidation potential occurs with onset of flowering in both sexes—a transition which seems generally to be correlated with a subsidence in cambial activity and diminution in rate of phloem differentiation. In dioecious forms such as hemp, nettle, and some varieties of spinach, both sexes excrete nitrogen, phosphorus, and potassium into the substrate at anthesis. In staminate plants such excretion is irreversible, but in pistillate plants merely transitory. Female plants more than recoup their original losses as fruiting is initiated. In mixed stands of the two sexes, this relationship quite obviously operates to the benefit of the pistillate plants.

### The Fruiting Phase

The transition of the plant from a flowering to a distinctly fruiting condition is often gradual in so far as anthesis of younger flowers usually continues after older ones have already set fruit. The fruiting stage is, however, metabolically distinct from that of an-

thesis. Concurrently with the early stages of fruit enlargement there occurs an important period of renewed anabolism in vegetative organs which restores the root and upper portions of the shoot to a condition approximating that which exists in the vegetative plant prior to flower formation. Water and nutrient absorption by roots are greatly accelerated while carbohydrate and protein synthesis in the shoot are accelerated. Despite the heavy demands of growing fruits, organic and inorganic reserves tend to increase temporarily in young leaves and vegetative parts, due to a rise in the net assimilatory rate. These metabolic transformations are systemic, and it is obvious that certain stimuli from developing fruits influence the entire plant. The resurgence in the growth and absorptive activity of the root are especially striking. There is frequent reference in agronomic literature to the marked efficacy of fertilizer amendments applied during this phase of growth.

As fruit set and enlargement accelerate, however, the nutrients are oriented increasingly to reproductive rather than to vegetative structures. Rapidly enlarging fruits and seeds often function as nutrient sinks to such a high degree that they not only absorb the current supply of organic and inorganic food from the root but rob the leaves at progressively higher levels of their protoplasmic constituents. Leaves gradually lose the power of direct synthesis of protein from inorganic nitrogen as well as the ability to reform proteins from proteolytic residues even in the presence of carbohydrate. The depletion of leaves, especially at the base of the shoot, commonly attains starvation levels, resulting in eventual death and abscission of such leaves before fruits have achieved maturity.

The increasing nutrient demand of enlarging seeds and fruits finally leaves the roots inadequately supplied, thereby again interfering with root growth and absorption. There ensues a final upturn in percentage dry weight of shoot tissues, which soon begin to manifest general symptoms of senescence as their moisture content falls to progressively lower levels. Terminal stages of development in many species are characterized by loss of appreciable quantities of potassium, nitrogen, and phosphorus to the substrate. Nutrient excretion marks the absorptive failure of the root, a systemic reduction of moisture content, and the beginning of general senescence of vegetative organs.

The foregoing discussion represents an attempt to trace the major events in the nutritional ontogeny of typical annuals, without meaning to imply, however, that the nutritional status is the prime or causative factor in control of development. Environmental factors in large measure determine the balance between vegetative and reproductive processes. Temperature and the photoperiod to a considerable degree determine the initiation of reproduction. Yet there is an important interdependence between vegetative and reproductive processes, as evidenced by the failure of photoperiodic induction in the absence photosynthesis or in the presence of large amounts of growth substances. The establishment of correlations between the nutrient status and specific stages of growth should, however, facilitate the work of the biochemist seeking to identify morphogenetic substances. At these stages of development certain inherent or autogenous factors come into play, and some processes, such as flower formation, to a large extent progress independently of environmental conditions. These stages of ontogeny seem to offer attractive possibilities to the biochemist in isolation and identification of specific formative compounds.

Currently there is active interest in the identification of additional morphogenetic agents and their relationship to particular types of metabolism, as exemplified by recent work on the role of auxin in water balance and mineral nutrition. Studies are also under way to determine the physiological mechanism whereby unsaturated hydrocarbons such as acetylene are able to induce flowering. The recent preparation of a naturally-occurring active extract from corn which is capable of initiating reproductive processes upon injection into other plants represents an important advance. In conclusion, it is evident that the progress in our knowledge of developmental physiology during the present decade has contributed substantially to an enlightened understanding of what plants really are, what they do, and how their life cycle is implemented.

# *Obituary*

## Max Planck
### 1858-1947

Max Planck died in Göttingen on October 4, 1947, shortly before his 90th birthday. By virtue of his introduction of the quantum hypothesis, he was the spiritual father of the modern development of physics and of the basic concepts of many other sciences and their epistomological interpretations.

He was born at Kiel, in north Germany, on April 23, 1858, the son of Wilhelm Planck, a noted jurist like many of his forebears. The family came originally from Schwaben, in south Germany. It was still farther to the south—namely, Munich in Bavaria—that Planck lived during the formative period of his youth. There he went to high school, and there he studied physics at the University. Life in that colorful town with its vigorous tradition in the liberal arts and the humanities greatly influenced his development during adolescence. After his graduation from high school, he wavered between three fields to which he might devote his life: the humanities, music, and physics. Planck gave up the idea of becoming a musician because he decided that his talent was not great enough; still, he was an excellent piano player and often conducted instrumental and vocal concerts in his home with the utmost finesse and deep musical understanding. He decided to become a theoretical physicist. Although keenly interested in the results of experiments, he left the ars experimentandi to others. From the very beginning of his academic career he confined himself to the interpretation rather than the performance of experiments, in spite of the fact that theoretical physics as a separate discipline did not at that time exist in Germany. Decisive for his final choice was the great inspiration he received from the fact that observations in the physical world can be ordered into a logical system. Such laws as the principle of the conservation of energy affected young Planck with the force of a revelation. It is thus understandable that he should have devoted his whole life to studies of the basic laws of nature.

His teachers in physics and mathematics in Munich (1875–77) did not inspire him, but they gave him many facts and interrelations of facts which served as material for Planck's own thoughts and associations. Even a year in Berlin (1878), where Helmholtz and Kirchhoff taught, did not release him from his mental isolation. Helmholtz, whose printed lectures are classics in clarity and beauty of language, must have been a terrible lecturer. He spoke in an inaudible voice, wrote in miniature letters on the blackboard, was unprepared, and often forgot his audience entirely. Kirchhoff, on the other hand, as Planck mentions in his scientific memoirs, gave well-worked-out lectures, but presented them like a memorized script, coldly and impersonally. Planck was therefore forced to base his scientific education on reading of the original literature. He was especially attracted by Rudolf Clausius' writings on thermodynamics, in which this author once and for all disposed of the idea that heat was something analogous to matter. Planck chose for the topic of his doctoral dissertation a thermodynamic subject. He received his degree in Munich in June 1879. There followed several papers on thermodynamics, centering around the concept of entropy—a concept originally introduced by Boltzmann but not applied by him to problems of thermodynamics proper. These papers aroused no interest among the physicists and chemists, just as was the case with similar papers written (prior to Planck's) by Willard Gibbs in this country, but unknown to Planck. When he became acquainted with Gibbs's publications, he acknowledged their priority and more general treatment.

These papers by Planck opened the way to an academic career. In 1880 he became privatdocent in Munich—however, not without clear hints from the famous organic chemist, von Bayer, that Planck's chosen field was a sterile and useless one. Five years later he was elected associate professor of physics at the university in his native town of Kiel. Lack of other suitable candidates apparently played a great role in this relatively quick promotion. Planck indicates modestly in his scientific memoirs that the fact that his father was a close friend of the chairman of the Physics Department in Kiel may have had some influence. Planck's publications during his professorship at Kiel include a book *Über das Wesen der Energie* ("About the Nature of Energy"), which received a prize from the academy in Göttingen, and papers on the increase of entropy in the course of chemical reactions. The latter provoked some controversies with Arrhenius and later with Ostwald. Of course, Planck was right, but it took some time before this was generally acknowledged. The great turning point in Planck's career came in 1889, when he received a call to the University of Berlin to be associate professor. He was promoted to a full profes-

sorship in 1892. In Berlin, Planck finally found congenial surroundings which, according to his own opinion, contributed more to the broadening of his scientific understanding than all his previous studies had done. Helmholtz, of course, made the greatest impression upon him. According to his contemporaries, Helmholtz was not only a great scientist whose clarity of mind and penetrating power of judgment everyone admired, but also a human being with a charming personality. However, his human greatness revealed itself only to the few who, like Planck, gained his respect and confidence. For his relations with the hoi polloi, Helmholtz wrapped himself in the robe of dignity becoming to his position as "Wirklicher Geheimer Rat." When Helmholtz became president of the Physikalisch Technische Reichsanstalt, which had just been founded, Kundt became director of the physical institute. His personality and vivid scientific mind attracted Planck very much. The friendship with Heinrich Rubens also started during these years.

After surveying the field of thermodynamics in a book which remained practically unchanged through 9 editions and still serves as one of the principal textbooks of this field in German universities, Planck's interest shifted to the thermodynamics of temperature radiation. It was not just chance that at that time the problem of temperature radiation attracted the minds of the very best physicists everywhere. It is rather one of the most interesting examples proving that pure science is not only the instigator of technological development but often is stimulated by technical progress to solve its most basic questions. Just as the great school of thermodynamics in England originated under the influence of Watt's invention of the steam engine, the pioneer work on temperature radiation can be traced to the inventions which improved the illumination of our houses. This is as true for the pioneer theoretical work of men like Kirchhoff, Rayleigh, Jeans, Boltzmann, Wien, and Planck as for the experimental work of Rubens, Lummer, Pringsheim, and others. The experiments of the last-mentioned group started in the Physikalisch Technische Reichsanstalt, as an attempt to use the blackbody radiation for the construction of standards for measurements of illumination intensities.

What was the situation? When the experimentally determined energy of the temperature emission of a black body was plotted against wave length, a curve was obtained with a maximum which shifts toward shorter wave lengths with rising temperature. At infinitely short wave lengths, the intensity goes down to zero and is again low in the region of very long wave lengths. Jeans and Rayleigh, who derived a radiation formula on the basis of the law of equipartition of energy between all degrees of freedom, expected an energy distribution curve of an entirely different character. Their curve is only in agreement with observation in the long wave length region, but has no maximum and deviates grossly in the region of short wave lengths. As a matter of fact, the theory predicted a continuous rise to infinity with declining wave length. Many attempts had been made in vain by the best scientists to overcome this difficulty. W. Wien derived a radiation formula which gave the maximum and was in accordance with observations in the short wave length region. Very careful measurements by Rubens and Pringsheim proved, however, that Wien's law failed to agree with observations in the long wave length region. Rubens kept Planck continually informed about the outcome of the experiments. Planck developed an empirical formula which, for long wave lengths, coincided with that of the Rayleigh-Jeans curve and, for short wave lengths, with Wien's formula. He sent it by postcard to Rubens, and it turned out to fit all observations perfectly. Planck realized that the classical thermodynamics, so very familiar to him, inevitably led to the Rayleigh-Jeans radiation law. Something was apparently fundamentally wrong with the laws of classical physics. One can imagine that that situation became a great challenge to Planck. He worked for months, as he admitted later, more intensely than he had ever worked before or ever would again. His goal was to find out which changes had to be introduced in the assumptions to arrive at a sound derivation of his empirical formula. To his utter astonishment, he found that the theory of the equipartition of energy had to be sacrificed and replaced by the revolutionary assumption that light was emitted and absorbed in energy units—quanta—whose size was proportional to the fundamental constant, $h$, and to the frequency of the light. He presented this result in a paper read at a meeting of the Berliner Physikalische Gesellschaft on December 14, 1900. This was the natal hour of the quantum theory which, in the course of its development, penetrated into and changed the concepts of practically every field of physics and chemistry; it is still conquering more and more territory in all sciences. It is difficult to say whether the joy of the discoverer prevailed in Planck or the regret that the classical approach to physics, so cherished by him, had failed dismally. He was by his very nature a classicist and by no means a romantic revolutionary. In his derivation of the radiation formula he tried to conserve as much as possible of the classical concept. This very fact introduced a kind of discordance into his theory.

Later (1916), Einstein gave a new derivation of Planck's formula which is now generally accepted. Einstein had no hesitation in going the whole way and removing every part of the classical theory not organically connected with the concept of the quantum theory. Planck, on the contrary, for years made every attempt to reconcile his formula as much as possible with the classical concept. For instance, he was pleased to find that his radiation equation could be derived by introducing the quantum hypothesis for light emission only and not for the absorption process. He did that like a man who, forced by irresistible circumstances to burn the bridges behind him, still casts longing glances toward the territory beyond the river. The writer still remembers vividly a talk which Planck gave at a colloquium in Berlin when the quantum theory was only a few years old (probably 1903). He spoke of some of his attempts to avoid the quantum hypothesis if possible. His conclusions, however, were the following: There is no way out; we have to become accustomed to the quantum theory, and we shall see that it will penetrate into more and more fields of our physics. He was more right than he himself could have anticipated. He could not foresee that our whole concept of the structure of matter would be based on the quantum theory; neither could he have had any presentiment of the future development of quantum mechanics, quantum electrodynamics, etc., which may still have the greatest surprises in store for the physicists.

Planck, who revolutionized science because he had to do so, became a kind of godfather to the second great revolution which shook the fundament of our science during his lifetime—Einstein's theory of relativity. He was one of the very first advocates of Einstein's ideas, and it was he who was responsible for Einstein's coming to Berlin and accepting a position at the Academy there and at the Kaiser-Wilhelm Institute. Planck was fascinated by Einstein's theory in all its phases, and he understood its implications much earlier than most of his contemporaries.

According to his own statement, Planck was especially attracted to the theory of relativity because of its content of absolutivity, meaning the unique position ascribed to the velocity of light. But that remark of Planck's was certainly not meant to be a sufficient explanation of his special interest in the theory of relativity. Revolutionary as it is in its introduction of entirely new concepts of space and time and in the unrelenting strictness with which statements sanctified by tradition were recognized as meaningless and cast away, still the theory of relativity is the keystone, missing for centuries, which perfected the structure of classical physics. That, the writer believes, is the real reason for Planck's strong affection for Einstein's work.

For 40 years Planck remained professor of theoretical physics in Berlin. Generations of physicists followed his lecture courses with enthusiasm because of the clarity and perfection of what he said, and with admiration for the personality of the man who said it.

With advancing age, heavier burdens of an administrative nature were heaped upon him. He felt the obligation to use his reputation for the benefit of science as a whole. He was one of the founders of the Berliner Physikalische Gesellschaft and was most active in the creation of the German Physical Society. He regularly attended the colloquium at the university and was to a great extent responsible for the fact that it was for many years unique, not only in the composition of its audience but in the excellence of the presentations and the breadth of the subjects discussed.

His duties as permanent secretary of the Berliner Academie took another part of his time. In addition, Planck later accepted the presidency of the Kaiser-Wilhelm Gesellschaft. The question arises whether Planck was a good administrator, and the answer depends upon the point of view. If to be a good administrator means to inspire in colleagues and subordinates the utmost confidence in the integrity and justness of their superior, then Planck was undoubtedly a good administrator. His opinions and judgment were often sought in cases not connected with his official duties.

Planck was still president of the Kaiser-Wilhelm Gesellschaft when Hitler rose to power. Certain of his friends and admirers hoped that in the name of science he would raise his voice in open protest against that kind of government and what it stood for. But that did not correspond to his character. The family tradition that the law is sacrosanct was too strong in him. He hated Hitler's laws, but they were the Law and therefore must be obeyed as long as they were in force. However, Planck thought that one could try to influence Hitler, to persuade him to mend his evil ways. He therefore asked for an interview with Hitler. He was courageous enough to say to the almighty dictator what he felt he had to say. He got his interview, but it was doomed to failure. As soon as Hitler found that what Planck wanted, he started a philippic which lasted for hours and which, if not as convincing as Cicero's, at least was delivered with equal power of voice. Planck did not resign from his position. He regarded it as his duty to save what he could of German science during the evil times of the Hitler regime, which he hoped and believed would be only of short duration. The Nazis used

Planck's name to further their own designs by printing a telegram of adulation supposedly sent to Hitler by Planck as president of the Gesellschaft Deutscher Naturforscher und Ärzte. With the newspapers completely under government control, it was impossible for Planck to have a denial printed.

The writer last saw Planck in 1935 on the occasion of a very brief trip from Denmark to Berlin. Planck was extremely unhappy. He responded to the proposal of a visit to Denmark to breathe the air of freedom for a few days in a manner typical of his thinking. He said, "No, I cannot travel abroad. On my previous travels I felt myself to be a representative of German science and was proud of it. Now I would have to hide my face in shame." Still, at that time, Planck did not imagine the total depths of depravity, insanity, and sadism into which Hitler was to lead Germany. He lived to experience it, well informed of what was happening by his second son, Erwin Planck. (His oldest son was killed in action during the first World War.) Erwin Planck, Secretary of State under Schleicher, was a man of the highest courage and integrity and an active foe of the Hitler regime. He later was involved in the unsuccessful plot against Hitler's life and in 1945 suffered a terrible death at the hands of the Gestapo.

When Hitler plunged the world into total war, Planck shared the fate of millions of his countrymen. His beautiful home in Grunewald near Berlin, including his library and all of his personal belongings, was destroyed by bombs. He had to leave Berlin and was trapped for hours in an air-raid shelter in Kassel, which had caved in from a hit. Temporarily he found a home with friends on a big farm near Magdeburg. When the war swept over that area, he and his wife were left shelterless. Finally he was rescued by some American colleagues, members of a scientific mission to Germany, who found him bent in pain from arthritis and brought him to a hospital in Göttingen. Planck's remarkable vitality overcame many of these mental and physical sufferings. It was the execution of his beloved son, Erwin, which finally destroyed his will to live. Although his health improved under the care of his wife in Göttingen, where they now lived in the house of a niece, he was a broken man whose world was shattered. During periods of better health he still felt it his duty to accept invitations for lectures. He used some of his older manuscripts on the relations between science and philosophy which he read to his audience. Death came to him as a redemption. So the life of one of the greatest scientists, upon whom the world had bestowed its highest scientific honors, ended in grief and misery.

May his memory live on in us; he was a great scientist and a man of integrity and justice.

JAMES FRANCK

*The University of Chicago*

Note: This obituary was presented as a memorial lecture on January 31, 1948, at the meeting of the American Physical Society in New York City, and has been published in the *Year Book* of the American Philosophical Society for 1947, pages 284–292.

# *NEWS and Notes*

**Alexander Brunschwig,** attending surgeon to the Memorial Hospital for the Treatment of Cancer and Allied Diseases, New York, and professor of clinical surgery at Cornell University Medical College, has been elected to honorary membership in the Vienna Surgical Society. Last year Dr. Brunschwig spent two months in Austria as a member of the Medical Teaching Mission of the Unitarian Service Committee and the WHO Interim Committee, giving lectures and surgical demonstrations in the surgical clinics of Vienna, Graz, and Innsbruck.

**W. Ralph Singleton,** geneticist at the Connecticut Agricultural Experiment Station, has been appointed senior scientist in the Biology Department of Brookhaven National Laboratory, where he will conduct investigations on the effect of atomic and other types of radiation on plant material. Dr. Singleton, who is widely known for his development of sweet corn hybrid varieties, has been on the staff of the Connecticut Station for 21 years.

**W. Taylor Sumerford,** professor of chemistry at Louisiana State University, has resigned and on June 1 will take up his new duties with the Technical Development Division, Communicable Disease Center, U. S. Public Health Service, Savannah, Georgia. Dr. Sumerford will be in charge of the Chemical Investigations Branch, which is engaged in research on chemical compounds used in controlling rodent and arthropod vectors and reservoirs of communicable diseases.

**Adriance S. Foster,** Department of Botany, University of California, has been appointed visiting lecturer in botany at the University of Illinois for the 1948 Summer Session, which extends from June 18 to August 14. Prof. Foster is to offer a course in Plant Anatomy and a seminar in Plant Morphology.

**S. P. Swenson,** assistant director of the Washington Experiment Stations (Pullman) and head of the Department of Agronomy, is on a four-month trip to Germany as a technical agricultural adviser to the military government. In his absence, **S. C. Vandecaveye,** chairman of the Soils Section, is acting head of the Depart-

ment, and **Luther Smith,** associate professor of agronomy, is acting chairman of the Farm Crops Section.

**Raymond B. Seymour** has resigned his position as director of the Industrial Research Institute, University of Chattanooga. Before joining this organization three years ago, Dr. Seymour was research group leader with the Monsanto Chemical Company, chief chemist for Atlas Mineral Products Company, and research chemist for the Goodyear Tire and Rubber Company.

**Gerald Goertzel,** of the Nuclear Physics Laboratory, Oak Ridge, Tennessee, has been appointed assistant professor of physics at Washington Square College, New York University. He will take up residence in September.

**W. W. Mutch** will be on leave of absence from Knox College next year to serve as acting head of the Physics Department at Wabash College. He replaces **Duane Roller,** who will be at Harvard University on a visiting appointment.

**H. R. Morgan,** for many years head of the 9-inch transit circle division of the U. S. Naval Observatory, recently retired, is now research associate in astronomy at Yale University, where he is carrying out investigations of fundamental star catalogues. This work is a part of a long-range project on the motions of the principal planets that was undertaken by the U. S. Naval Observatory, Yale University, and the Watson Scientific Computing Laboratory, with the support of the Office of Naval Research. **Raynor L. Duncombe,** associate astronomer at the U. S. Naval Observatory, has temporarily been assigned to duty at the Yale Observatory for work on this project.

**Otto Loewi,** research professor of pharmacology, New York University College of Medicine, and, with Sir Henry Dale, Nobel Prize winner in medicine in 1936, is the current visiting scholar of the Richmond Area University Center. For the duration of his visit (May 10–28), he is giving a series of three technical lectures and five lectures of a more general nature at the various institutions affiliated with the Center. In addition to the lectures, Dr. Loewi is discussing informally with students and staff research problems in experimental biology.

**George H. Acheson,** who has been a member of the staff of Harvard Medical School since 1939, will become head of the Department of Pharmacology at the University of Cincinnati on July 1. He succeeds **Dennis E. Jackson,** who plans to retire.

**Julius Sendroy, Jr.,** professor of chemistry and chairman of the Department of Experimental Medicine at the Loyola University School of Medicine (Chicago), has been appointed to the newly created post of associate research executive, in charge of chemistry, at the Naval Medical Research Institute, National Naval Medical Center, Bethesda, Maryland.

**Harold J. Conn,** professor of bacteriology in the Division of Food Science and Technology, New York State Agricultural Experiment Station, Geneva, New York, retired May 1 in order to devote full time to the affairs of the Biological Stain Commission. Dr. Conn has been a member of the Station staff since 1911 and this year is president of the Society of American Bacteriologists.

**William A. Nierenberg,** at present an instructor of physics at Columbia University, has been appointed assistant professor at the University of Michigan beginning with the 1948–49 academic year.

## Visitors to U.S.

**C. C. Cheo,** of the National Tsing Hua University, Peiping, China, arrived in this country on April 12 from England, where for the past two years he has been studying plant virus pathology at Cambridge University with Kenneth M. Smith. During his several months stay in the United States he is conferring with specialists in various research institutions. He will return home from San Francisco.

**Holger Hydén,** of the Institution for Cell Research, Karolinska Institutet, Stockholm, Sweden, recently lectured on "Nucleoproteins, Cell Growth and Function" before the General Physiology Seminar at the University of Minnesota. Dr. Hydén was the third in a series of speakers which has included Saul Spigelman, Washington University, St. Louis, and Henry Bull, Northwestern University. The seminar, which runs throughout the year, is sponsored jointly by the Departments of Zoology and Botany, and the Departments of Physiology and Physiological Chemistry of the Medical School.

## Grants and Awards

**The Nutrition Foundation, Inc.,** has announced the authorization of the following grants-in-aid: $7,950 annually for 2 years to the University of Toronto (C. H. Best), for continuation of studies of the physiological lipotropic factors; $9,000 to Harvard University (F. J. Stare), for continuation of studies on the effect of diabetes upon nutritional requirements and the experimental production of hardening of the arteries, and the effect of nutritional deficiencies upon heart muscle; $5,000 to the University of Rochester (K. E. Mason), for a study of the chemical nature and metabolic significance of a pigment associated with vitamin E deficiency; $14,000 to Columbia University (C. G. King), for a study of the functions of vitamin $B_c$ and C; $3,500 annually for 3 years to the University of Wisconsin (C. A. Elvehjem and P. H. Phillips), for a study of the relation of nutrition to dental caries; $3,500 annually for 2 years to the University of Wisconsin (C. A. Elvehjem), for continuation of studies on the effects of other dietary components on the quantitative requirements of amino acids; $2,500 annually for 2 years to Johns Hopkins University (E. V. McCollum), for a study of new procedures for separating amino acids; $2,500 annually for 2 years to the State College of Washington (T. J. Cunha and M. E. Ensminger), for continuation of studies of the nutritional importance of vitamin B-complex for the pig; $2,000 annually for 2 years to the University of Wisconsin (H. A. Lardy), for studies of the metabolism of fats; $850 to Stanford University (J. M. Luck and C. P. Stone), for a study of the effect of feeding glutamic acid upon the learning process in rats;

$3,500 annually for 2 years to Massachusetts General Hospital (F. Lipmann and W. Bauer), for continuation of studies of the role of acetates in the synthesis of body constituents; $3,000 annually for 2 years to Iowa State College (R. R. Sealock), for a study of the metabolic role of vitamin C; $1,800 annually for 3 years to the University of Rochester (F. C. Steward), for a study of separation and determination of nitrogenous constituents of plants; $3,600 to Oregon State College (V. H. Cheldelin), for a study of assay methods and the functional role of vitamins of the B-complex; $800 annually for 2 years to the University of Tennessee (J. L. Wood), for a study of the role of alpha keto acids in intermediary metabolism; $2,000 to Columbia University (H. C. Sherman), for continuation of studies of the quantitative relation of vitamin A intake to bodily store and well-being at different ages; $1,500 to the University of Pittsburgh (E. M. Scott), for continuation of studies on self-selection of diets; and $3,800 annually for 3 years to Harvard University (F. J. Stare), for research in nutrition education.

According to George A. Sloan, president of the Foundation, 158 grants-in-aid totaling $1,635,130 have been made to 60 universities and medical centers since the Foundation's organization in 1942.

**The American Academy of Arts and Sciences** announces the awards of the following grants-in-aid from the Permanent Science Fund: to Lincoln Constance, University of California, visiting professor at Harvard University and acting director of the Gray Herbarium, for travel for field study in Texas on the mode of origin of certain wild plant species, $350; to Kenneth J. Conant, School of Design, Harvard University, for aid in a three-dimensional study of a medical monastic group which formerly existed at Cluny in Burgundy, $425; to Hallam L. Movius, Jr., Peabody Museum, Harvard University, for a supplementary grant for his study of Paleolithic culture in the USSR, publication of which has been assured from another source, $750; to Bernard F. Riess, Department of Animal Behavior, American Museum of Natural History, for aid in a study of relation of diet to susceptibility to audiogenic and stress shock, $1,000; to Alexander Forbes, Harvard Medical School, for continuation of study of refractory phase in cerebral mechanism, $300; and to William M. Ingram, Department of Zoology, Mills College, for completion of a study of "Fossil and Recent Cypraeidae of the Eastern Regions of the Americas," $360.

Income from the Fund is available for encouragement of research in any field of physical, mathematical, or social science whatsoever, the results of which shall be made fully available to the public. An award normally does not exceed $1,500, but a few grants of substantially larger amount will be available for especially meritorious projects from the income accumulated and unexpended during the war years.

The next meeting of the Permanent Science Fund Committee, in October 1948, will consider applications received up to October 1 on forms which may be secured from the Chairman, John W. M. Bunker, Massachusetts Institute of Technology, Cambridge 39, Massachusetts.

**A $700,000 Rockefeller Foundation grant** ($100,000 a year for 7 years) has just been made to California Institute of Technology in support of its long-range program of basic research in biology and chemistry. The new basic knowledge in these two fields which CalTech scientists hope to discover is expected to aid in developing future treatments for cancer, poliomyelitis, and other of the most serious ailments.

**The Arctic Institute of North America** has announced that a total of approximately $5,000 is available for several senior grants-in-aid for scientific work in the North American Arctic and Subarctic during 1949. Research must include field investigations in Alaska, northern Canada, Labrador, Newfoundland, or Greenland. Applications for these grants, which are open to anyone who has demonstrated his ability to carry out research work of superior quality in some field of science, must be received by November 1, 1948. Forms are obtainable from the Institute's offices at 805 Sherbrooke Street West, Montreal, Canada, or Audubon Terrace, Broadway and 156th Street, New York City 32.

**The Johannes Schmidt Medal in Gold** was awarded on April 17 to Henry B. Bigelow, professor at Harvard's Museum of Comparative Zoology, in acknowledgment of his very significant contributions to physical and biological oceanography. The medal was awarded by the Professor, Dr. phil. Johannes Schmidt's Foundation for Oceanography, Denmark.

**Robert L. Usinger,** assistant professor of entomology at the University of California, Berkeley, has been awarded a National Institute of Health Special Research Fellowship for the academic year 1948–49. Dr. Usinger will spend the year on sabbatical leave studying Hemiptera in Brussels, Paris, Stockholm, and London, with headquarters at the British Museum (Natural History), London.

**The Hanlon Award,** the highest received in the natural gasoline industry, was presented to Col. George A. Burrell, president of Burrell Technical Supply Company, Pittsburgh, Pennsylvania, during the recent annual meeting of the Natural Gasoline Association of America at Fort Worth, Texas. Col. Burrell was responsible for the development of a process which led to the first separation and recovery of liquefied petroleum gases, and also pioneered in the application of low-temperature methods to the fractional distillation of light hydrocarbon gases. The Hanlon Award is made each year for outstanding service to the natural gasoline and cycling industries.

## Summer Programs

**The Duke University Marine Laboratory,** Beaufort, North Carolina, will offer a course in marine zoology from June 15 to July 24, and a course in structure and classification of the algae from July 26 to September 3. The former will be taught by I. E. Gray, chairman of the Department of Zoology at Duke; the latter, by H. L. Blomquist, chairman of the Department of Botany.

Opportunities to do research or pursue special problems will be offered

graduate students by members of the laboratory staff. Facilities for investigators are still available for the latter half of the summer.

**The U. S. Atomic Energy Commission** has instituted fellowships to be granted to well-qualified investigators who wish to work with radioactive isotopes at the Marine Biological Laboratory this summer. Each Fellow will receive $250 and round-trip traveling expenses from his university. Laboratory fees will be paid by the Commission. The work with isotopes will be under the general supervision of G. Failla, of the Department of Radiology, Columbia University. Applications for these fellowships should be addressed to: Dr. Charles Packard, Marine Biological Laboratory, Woods Hole, Massachusetts.

**Establishment of a Marine Research Laboratory** at Ocean Springs, on the Mississippi Sound, has recently been authorized by the Mississippi legislature. The Laboratory, which is sponsored by the Mississippi Academy of Science, will have R. L. Caylor, Delta State College, Cleveland, Mississippi, as its acting director. Courses in marine zoology, taxonomic botany, and geology (marine sedimentation) will be offered this summer, and some facilities for research will also be available.

## Industrial Laboratories

**Charles W. Deane,** who for the past 7 years has been head of the Chemical Engineering Department and principal process engineer with Colgate-Palmolive-Peet Company, has been appointed chief engineer of E. R. Squibb & Sons. Dr. Deane will head all Squibb engineering activities, both domestic and foreign.

**Alexander N. Winchell,** resident consultant at the Stamford Research Laboratories of the American Cyanamid Company for the past three years, has resigned and will renew his activities as a consulting geologist and crystallographer. His new headquarters are located at 88 Vineyard Road, New Haven 14, Connecticut.

**Albert B. Scott,** formerly director of research and development of the Norwich Pharmacal Co. (and Eaton Laboratories), has joined the scientific staff of Merck & Co., Rahway, New Jersey.

**Eastman Kodak Company** recently announced the successful recording of electron tracks by use of a new photographic emulsion developed by scientists in the company's laboratories. These tracks, first obtained at Kodak's laboratories at Harrow, England, and later at Rochester, New York, have been produced by directing X-rays toward the emulsion through a sheet of lead. As the X-rays pass through this lead filter, they knock loose secondary photo-electrons. One of these, speeding into the emulsion, strikes and affects silver grains, producing a dotted line of the affected grains. Upon development, the plate shows an identifiable track—the path of the electron through the emulsion. From the length of the track (only about two thousandths of an inch, or two-thirds the thickness of a sheet of paper), its curvature, and the spacing of the grains along it, it is possible to obtain information concerning the speed of the electron and other characteristics. Eastman scientists hope that the new procedure will provide a valuable tool for studies of atomic disintegration, of cosmic rays, of radioactive isotopes as applied in medical research, and in autoradiography.

## Meetings and Elections

**The annual Field Conference of Pennsylvania Geologists** is to be held in Harrisburg May 28–30, inclusive, the Pennsylvania Topographic and Geologic Survey serving as host. S. H. Cathcart, director, is chairman of the local committee.

A feature of the meeting will be an all-day excursion on May 29 over the Pennsylvania Turnpike to the Allegheny Front, under the leadership of A. B. Cleaves, of Washington University, St. Louis, former geologist for the Pennsylvania Turnpike Commission. During the three-day meeting excursions will also be made to the South Mountain area, the Cornwall magnetite deposit, and along the Susquehanna-Juniata Rivers, with G. L. Adair, R. M. Foose, D. M. Fraser, F. W. Swartz, and B. Willard participating as leaders.

At a smoker on Friday evening, a program on the airborne magnetometer and applications of aerial photographs to geology will be presented by the Aero Service Corporation, Philadelphia, which will also sponsor a social hour. On Saturday evening there will be a dinner, followed by a short business meeting and motion pictures.

Registration for the Conference will be held in the Survey Offices, 604 South Office Building, Harrisburg, on the morning of May 28. Additional information may be obtained from M. N. Shaffner, secretary-treasurer of the Conference, c/o Pennsylvania Topographic and Geologic Survey, Harrisburg.

**The spring meeting of the Society for Applied Anthropology** will be held at University Museum, 33rd and Spruce Streets, Philadelphia, May 28–30. On Friday there will be two sessions, one on Theory and Method, which will consist of a round-table discussion on Personality Structure and Social Organization, and the other on Industry, at which Development and Maintenance of Group Equilibrium in Industry will be discussed. On Saturday there will also be two major sessions. That on Social Psychiatry will deal with Mental Health and World Citizenship (with particular reference to the International Conference on Mental Hygiene, to be held in London next August), while the session on Resettlement and Regional Rehabilitation will be devoted to reports on the Latin-American Program of the Office of Foreign Agricultural Relations (USDA), the Program of the Inter-American Institute of Agricultural Sciences in Costa Rica, and the Programs of the Kellogg Foundation and the Rural Resettlement Institute. The annual dinner and business meeting will be held Saturday evening and Sunday morning, respectively.

**The American Psychopathological Association** will hold its annual meeting June 4–5 at the Commodore Hotel in New York City. This year's symposium, the topic of which will be "Psychosexual Development in Health and Disease," will consist of four sessions: Orientation, Anthropological Approach, Clinical and Psychodynamic Approach, and Sociological Approach.

**The Fourth Congress of the International Society of Orthopaedic Surgery and Traumatology** is to be held in Amsterdam, September 13–18. The president of the Congress, Henry W. Meyerding, Mayo Clinic, 102–110 Second Avenue, S.W., Rochester, Minnesota, states that any orthopedic surgeon who may be in Europe at that time and wishes to attend the scientific and social functions of the Congress should notify him, at the above address, of time of arrival in order that proper reservations may be made.

**A Symposium on Cerebral Mechanisms and Behavior,** to be held in Pasadena, September 20 through 25, has been announced by the Trustees of the Hixon Fund of California Institute of Technology. The speakers will be Ward Halstead, University of Chicago Medical School; Heinrich Klüver, University of Chicago; Wolfgang Köhler, Swarthmore College; K. S. Lashley, Harvard University; R. Lorente de Nó, Rockefeller Institute for Medical Research; Warren S. McCulloch, University of Illinois College of Medicine; and John von Neumann, Institute for Advanced Study. Further information and hotel reservations may be obtained by writing Lloyd A. Jeffress, Kerckhoff Laboratories of Biology, California Institute of Technology, Pasadena 4, California.

**At the 8th annual meeting of the Association of Geology Teachers,** held at Hanover College, Hanover, Indiana, April 9–10, William F. Read, Lawrence College, was elected president; Leland Horberg, University of Chicago, vice-president; Katherine Greacen, Milwaukee-Downer College, secretary-treasurer; and Percival Robertson, Principia College, editor. Committees were set up to study geology curricula and standards, to promote the exchange of ideas and material, and to accumulate historical data on the teaching of geology in the United States.

Membership in the organization is open to any teacher of geology at the college or university level. Those interested are invited to communicate with the secretary of the Association.

**The Eastern Psychological Association,** at its meeting at Temple University, Philadelphia, April 16–17, elected Otto Klineberg, Columbia University, president for 1948–49, and Clarence H. Graham, Columbia University, and Anne Anastasi, Fordham University, directors for 1948–51. Harold Seashore, of the Psychological Corporation, 522 Fifth Avenue, New York City, is secretary.

**The National Association of Science Writers,** at its semiannual meeting in Washington, D. C., on April 28, elected the following officers for 1948–49: Steven M. Spencer, of the *Saturday Evening Post,* Philadelphia, president; F. B. Colton, of the National Geographic Society, Washington, D. C., vice-president; and Marguerite Clark, of *Newsweek,* 152 West 42nd Street, New York City, secretary-treasurer (re-elected).

**The National Academy of Sciences,** at its annual meeting held in Washington, D. C., April 26–28, elected William J. Robbins, director of the New York Botanical Garden, treasurer for a four-year term beginning July 1. (Other officers of the Academy are: president, A. N. Richards; vice-president, L. P. Eisenhart; foreign secretary, D. W. Bronk; home secretary, F. E. Wright.) Carl R. Moore, professor of zoology, University of Chicago, and J. Robert Oppenheimer, director, Institute for Advanced Study, Princeton, New Jersey, were newly elected to membership on the Council of the Academy for a three-year term.

The following were elected to membership in the Academy:

Eric G. Ball, professor of biological chemistry, Harvard Medical School.

Lloyd V. Berkner, chairman of the Section of Exploratory Geophysics of the Atmosphere, Carnegie Institution of Washington.

Felix Bloch, professor of physics, Stanford University.

Gerty T. Cori, fellow and research associate in pharmacology and biochemistry, Washington University School of Medicine, St. Louis.

Hallowell Davis, director of research, Central Institute for the Deaf, and research professor of otolaryngology, Washington University, St. Louis.

John R. Dunning, professor of physics, Columbia University.

W. Maurice Ewing, head of the Department of Geophysics, Columbia University.

Karl Folkers, assistant director of research, Merck & Co., Rahway, New Jersey.

Thomas Francis, Jr., professor of epidemiology and chairman of the department, School of Public Health, University of Michigan.

Edwin R. Gilliland, professor of chemical engineering, Massachusetts Institute of Technology.

Haldan K. Hartline, associate professor of biophysics, Hospital of the University of Pennsylvania.

Ernest R. Hilgard, chairman of the Department of Psychology, Stanford University.

Frank L. Horsfall, Jr., member, Rockefeller Institute for Medical Research, New York City.

John R. Johnson, professor of chemistry, Cornell University.

Raymond A. Kelser, dean, School of Veterinary Medicine, University of Pennsylvania.

Cyril N. H. Long, chairman of the Department of Physiological Chemistry, Yale University School of Medicine.

Edward J. McShane, professor of mathematics, University of Virginia.

Donald H. Menzel, chairman of the Department of Astronomy, Harvard University, and associate director for solar research, Harvard College Observatory.

C. W. Metz, chairman of the Department of Zoology, University of Pennsylvania.

Curt P. Richter, associate professor of psychobiology, Johns Hopkins University.

Hermann I. Schlesinger, professor of chemistry, University of Chicago.

Francis O. Schmitt, head of the Department of Biology and Biological Engineering, Massachusetts Institute of Technology.

Glenn T. Seaborg, professor of chemistry, University of California, Berkeley.

Gilbert M. Smith, professor of botany, Stanford University.

Curt Stern, professor of zoology, University of California, Berkeley.

Chester Stock, professor of paleontology, California Institute of Technology.

James B. Sumner, professor of biochemistry, Cornell University.

Edward Teller, professor of physics, University of Chicago.

Kenneth V. Thimann, associate professor of botany, Harvard University.

Charles A. Thomas, executive vice-president, Monsanto Chemical Company, Dayton, Ohio.

Dr. Cori is the fourth woman to be elected to membership in the Academy. Others so honored include Florence R. Sabin (1925), Barbara McClintock (1944), and the late Margaret Floy Washburn (1931).

The Academy also elected two foreign associates: Ronald A. Fisher, Arthur Balfour professor of genetics at the University of Cambridge and one of the world's leading statisticians, and Prince Louis de Broglie, professor of theoretical physics at the University of Paris (Sorbonne).

## Deaths

**Emmanuel Chapman,** 43, assistant professor of psychology and philosophy at Hunter College, died April 17 in New York Hospital.

**Lloyd Cady Daniels,** 64, assistant director of the general technical division of the American Cyanamid Company, died April 21 in New York Hospital.

**Aldo Leopold,** 62, chairman of the Department of Wildlife Management, University of Wisconsin, died of a heart attack April 21, near Baraboo, Wisconsin.

**Ivy C. Fisher,** 59, professor of philosophy and psychology at Wells College since 1919, died April 22 in Auburn, New York.

**Gayle Scott,** 53, professor of geology at Texas Christian University, died May 2.

**William Wilson,** 61, professor of physics at North Carolina State College and former vice-president of the Bell Telephone Laboratories, died May 6 in Raleigh, North Carolina.

**Cyril O. Bratley,** 44, a member of the scientific staff of the U. S. Department of Agriculture since 1928 and recently assistant to the administrator of the Department's Research and Marketing Division, died May 9 in Bethesda, Maryland. Dr. Bratley was widely known for his research on fruit and vegetable diseases.

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**The American Institute of Physics** has recently published the first issue of *Physics Today,* a semipopular monthly magazine designed to interpret rapid strides being made in the science of physics. Most of the articles appearing in the new magazine, which is edited by David A. Katcher, physicist and science writer, will be written by scientists. The leading article in the first issue, written by Vannevar Bush, wartime director of OSRD and now head of the Research and Development Board, is entitled "Trends in American Science." Other contributors include Arthur K. Solomon, of the Harvard Medical School, who writes on "Physics and Cancer," Stephen White, science writer for the *New York Herald Tribune,* whose topic is "A Newsman Looks at Physicists," and David L. MacAdam, of Kodak Laboratories, who reports on the International Conference on Color Vision in London. *Physics Today* is divided into various departments of interest to both physicists and those working in other fields.

**Microfilms of medical materials** are now being loaned free to research workers as the result of a change in policy by the Army Medical Library. The films, which may be retained for 90 days, should be requested on standard order forms through local libraries, government agencies, or research institutions. Those wishing to keep the films permanently and those who desire photostats may, as heretofore, obtain them at $.50 per unit.

**Although a final evaluation of the observations of the May 8–9 "annular" eclipse** will probably not be available for several weeks because of the lengthy computations involved, the National Geographic Society, on the basis of reports from the 7 stations which were dotted along a 5,320-mile arc from Burma to the Aleutians (see *Science,* February 13, p. 164), has termed the results "thoroughly worth while." At two of the observation sites—Bangkok, Siam, and Rebun Jima, off the northwest tip of Japan—good observing conditions prevailed. However, members of the expeditions located in China and Korea and on Adak Island in the Aleutians were prevented from making any observations because of a heavy cloud cover, and parties at a second point on Adak and in Burma rated their results doubtful because of cloud interference. Lyman J. Briggs, chairman of the Society's Research Committee, has stated that success of the observations at Rebun Jima and Bangkok means that the greater British Indian geodetic triangulation network could be tied in with that of Japan, and possibly Korea. Although ground observations were virtually impossible at the Aleutian stations, two specially equipped U. S. Air Force Superforts which penetrated the overcast and snow storm obtained excellent photographic results. If study of the photos confirms the complete success of the B-29 mission, it may also be possible for the first time to tie in the U. S.-Canadian geodetic survey networks directly with Asiatic systems—the No. 1 objective of the entire project.

This week's cover photo was taken as the Wu-k'ang, China, station prepared for the eclipse. Conferring beside a geodetic bench mark used to locate their observation site are Rev. F. J. Heyden, S. J., director of Georgetown College Observatory, Washington, D. C., chief astronomer of the China group, and Yu-Che Chang, director of the Astronomical Research Institute, Kunming, who acted as assistant astronomer.

**The National Registry of Rare Chemicals,** 35 West 33rd Street, Chicago 16, Illinois, lists the following wanted chemicals: 2,2′-diaminodiethyl ether; 1,4-diaminocyclohexane; ribose-1-phosphate; quinitol; phloroglucitol; mercaptopyruvic acid; mercaptosuccinic acid; *cis*-decahydro-1-naphthol; ß-eucaine hydrochloride; epicarin; 1,3-decadiene; 1,3-heptadiene; galactoflavin; stannous fluoride; 2-hydroxycaprylic acid; 1-vinyl-1,3-cyclopentadiene; 1-vinyl-1-cyclopentene; vinylanthracenes; *trans*-4-cyclohexyl-2-heptene; trans-4-cyclohexyl-2-pentene; auxin A; and auxin B.

# *Comments and Communications*

## The Informal Research Laboratory—A Proposal

One of the areas of international cooperation which has consistently functioned with maximum goodwill has been the informal research laboratory. The examples set by the Marine Laboratories at Naples and at Woods Hole need not be detailed here. During the summer months, research workers, freed of their teaching duties of the academic season, come from universities and laboratories all over the world to spend their vacation time together in discussion and research. The opportunities for free exchange of ideas, the deeper insight into the problems of the individual scientist, and the stimulation derived from working together closely are of inestimable value both to the scientists themselves and to the cause of international understanding.

Unfortunately, only a few such laboratories for informal research are open to scientists throughout the world, and these few institutions are restricted to a definitely circumscribed group of sciences. I know of no such laboratory devoted to chemical or to physical research. The emphasis has been mainly on the sciences related to marine biology.

In view of the proven benefits to be derived from such institutions and the paucity of adequate installations for the several sciences, I believe it would be advantageous for such an organization as UNESCO to investigate the feasibility of sponsoring and initiating such laboratories. It would emphasize the purpose of such an international laboratory if its foundations would be set by an organization devoted to the interchange of scientific information among investigators throughout the world.

Ideally, such a laboratory should be established for each of the scientific specialties or for groups of sciences where the pattern of research would suggest practical combinations. As a specific example, one laboratory might be devoted to the physiology and biochemistry of mammals. Facilities should include most of the basic instruments of research. In this case, an ultracentrifuge, adequate instrumentation for work with radioactive tracers, and an adequate animal colony might be considered as some of the requisite facilities. The laboratory should be planned to accommodate a group of 200–300 qualified investigators during the "season," with a permanent staff as required for the maintenance of the plant and for technical assistance.

Choice of the location of the existing Marine Laboratories was dictated, to some extent at least, by the marine flora and fauna in the waters adjacent to the selected areas. Similar considerations of special requirements might be desired in certain of the installations here considered, but since the basic materials for research can now be accumulated at any point, other factors should be considered. For example, the purpose of disseminating information might be served better if the location chosen were somewhat removed from the calculated center of concentration of scientists. On the other hand, the location should not be so remote as to make emergency equipment and supplies too difficult to obtain. Since investigators would be expected to spend their vacations at the laboratory, it should be located in a region which has some of the attributes of a desirable vacation area (certainly the case with the Woods Hole Laboratories!).

Details for the operation of the laboratory, for the financing of the venture, for mechanics of invitation of qualified investigators, and a host of other problems should receive careful attention, but at the moment, it is merely the general proposal which I should like to present for discussion among the members of the AAAS. More concrete proposals might be formulated at the forthcoming meetings of the Association.

CHESTER HYMAN

*University of Southern California Medical School*

## The Norton County, Kansas, Meteorite

Fragments from the large detonating bolide that startled the inhabitants of several Midwestern states on February 18 were recovered and identified on April 28 by an expedition sent into the field by the Institute of Meteoritics of the University of New Mexico. Most of the specimens so far recovered have been found on one of the farms of G. W. Tansill in Sections 12 and 13 of Rock Branch Township in Norton County, Kansas, but the largest specimen recovered, a mass weighing over 100 lbs, was recovered on the McKinley ranch in Section 1 of this township. All specimens recovered to date have been either donated to or purchased by the University of New Mexico.

The Norton County meteorite belongs to the rare class of achondrites and, while presenting many points of similarity to the remarkable Cumberland Falls Whitleyite, possesses certain features so distinctive that it seems quite possible that it will serve as the type stone of a new class of achondrites.

A detailed report on the field survey resulting in recovery of the meteorite and a description and analysis of the specimens recovered will be published in the near future.

LINCOLN LAPAZ

*University of New Mexico*

## A Proposed Petition to the International Commission on Zoological Nomenclature

The numerous applications now before the International Commission on Zoological Nomenclature, requesting exercise of the Plenary Powers for Suspension of the International Rules and establishment of a number of nomina conservanda, are commanding considerable interest among zoologists. The large number of applications, it is true, has resulted in part from the long hiatus in nomenclatural activity followed by a postwar revival of

interest in nomenclature. Nevertheless, the number has become overwhelming, both for the Commission members who must study them and pass upon their merits and for zoologists who should give them thorough consideration in order that the Commission may have the benefit of various points of view. Some applications, moreover, are too briefly presented and inadequately justified, though the burden of proof should rest on the applicant.

It is generally recognized that letters from scattered workers are a less effective means of demonstrating approval or disapproval than expression by groups of workers. Accordingly, the undersigned subcommittee of the Smithsonian Institution Committee on Zoological Nomenclature, composed of taxonomists of the U. S. National Museum, the Bureau of Entomology and Plant Quarantine, the Geological Survey, and the Fish and Wildlife Service, has drawn up the following statement, in the hope that it will crystallize opinion and serve as the basis for representations to the Commission. The full Committee has approved the petition and directed the subcommittee to publish it for consideration by other zoologists.

Zoologists are invited and urged to send their reactions to the petition to the undersigned as soon as possible, with the understanding that the Committee will transmit this petition together with all names and comments, both supporting and disagreeing, to the International Commission. All communications at hand will be sent to the Commission in time for the International Congress of Zoology at Paris in July 1948. In order to aid the work of the Committee and to avoid misinterpretation, it is requested that, if possible, a brief and unambiguous statement of approval or disapproval be given, though as much other comment may be added as the individual wishes.

### *On the Use of the Plenary Powers to Establish Nomina Conservanda*

It is not the immediate purpose of the undersigned to discuss the merit of individual proposals now pending, but to present their views on the general question of the use of the Plenary Powers by the Commission.

We believe that the International Rules of Zoological Nomenclature offer a sound foundation for ultimate stability and uniformity. In theory, at least, a standard to which there is no exception is a more solid basis than a standard whose application is weakened by numerous exceptions. In most cases, taxonomists could apply the Rules strictly, with little or no confusion and only a little inconvenience. On the other hand, we recognize that due consideration should be given to common usage of important names by the great body of nontaxonomists, the general zoologists, physiologists, medical men, teachers, and applied zoologists of all kinds. It is reasonable to conclude that the over-all objectives of stability and uniformity would be distinctly furthered if zoologists would agree upon some basic standards satisfactory to both viewpoints.

In the case of a specific or generic name transferred to a different species or genus (e.g. the transfer of the specific name *malariae* from the quartan malaria parasite to the malignant tertian, if the Rules are strictly applied), both the element of inconvenience and that of confusion are involved. Such a situation is likely to present adequate grounds for suspension of the Rules. Misidentified genotypes commonly result in transfers, though not all such cases are of sufficient importance to merit suspension.

Changes resulting from straight synonymy usually cause inconvenience rather than confusion. Experience indicates that even apparently serious changes of this nature can soon become commonly accepted (e.g. the change from *Stegomyia fasciata* to *Aëdes aegypti* for the yellow fever mosquito). Such changes, accordingly, are not grounds for Suspension unless better reason can be demonstrated.

If too many suspensions are allowed, or if suspensions are allowed on weak or unconvincing evidence, the value of the Rules as a basis for stable nomenclature would be depreciated. We are convinced that the International Commission should as soon as possible reassure zoologists that such will not happen. We therefore petition the Commission to set forth some general standards concerning applications for suspension of the Rules and respectfully suggest the following for consideration:

(1) Applications for suspension of the Rules should be *required to demonstrate* that strict application of the Rules would result in *far-reaching and substantial confusion* in the taxonomic use of names and/or in a lamentable change that would *greatly confuse* the literature of a related field (e.g. ecology, malariology, stratigraphic paleontology).

(2) Demonstration of confusion should include adequate bibliographic data showing the amount of usage and the percentage of uniformity. Mere assertion of "greater confusion than uniformity," unsupported by these data, should be considered inadequate.

(3) The Secretary of the Commission should return for additional evidence any application that does not contain the above demonstration and data.

(4) When an application that appears to satisfy the above requirements has been received and notice of its pending consideration has been published, the Commission should on its own initiative actively solicit—not merely passively await—the advice of specialists or other interested and qualified persons or groups from a variety of countries, museums, societies, and educational institutions.

Concerning the method to be employed by the Commission in actively soliciting advice on cases under consideration, it is suggested that, in addition to the regular published invitation to all interested individuals, use be made of existing national, society, and institutional committees on nomenclature, or that special panels in the various branches of taxonomic zoology be established for the purpose. These panels might be headed by, or liaison with them maintained by, various members of the Commission, in order to relieve the Secretary of the extra burden of of these contacts.

CURTIS W. SABROSKY and R. I. SAILER
*U. S. National Museum, Washington, D. C.*

# *Association Affairs*

Frank Leslie Campbell has resigned his editorship of *The Scientific Monthly* to become assistant to the administrator, Agricultural Research Administration, USDA, Washington, D. C.

## Pacific Division Meeting

The 29th annual meeting of the Pacific Division, AAAS, will be held on the campus of the University of California at Berkeley, June 21–26.

Registration will open Monday morning, June 21, at 9:00 o'clock. The first general session, to be held Monday afternoon, will be the divisional symposium on "The Biological Effects of Atomic Energy." On Tuesday morning there will be a symposium, under the auspices of the Pacific Science Board of the National Research Council, on "Recent Field Investigations in Micronesia and Adjacent Areas."

The address of Roy E. Clausen, president of the Pacific Division, will be given Tuesday evening, June 22. Dr. Clausen's subject will be "The Evolution of Cultivated Plants."

Nineteen societies associated or affiliated with the Division will participate in the Berkeley meeting, with symposia and sessions for submitted papers.

Local arrangements are in charge of a General Committee, of which M. A. Stewart, acting dean of the Graduate Division, is chairman. (ROBERT C. MILLER, *Secretary.*)

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The American Chemical Society Section of the Pacific Division, AAAS, which is meeting in Berkeley, California, June 22–23, has arranged a program consisting of two symposia and two sessions devoted to the presentation of scientific papers. On the morning of June 22 there will be a symposium on "Organic and Biological Chemistry." W. G. Young, University of California at Los Angeles, will discuss "Allylic Rearrangements"; Carl Niemann, California Institute of Technology, "The Blood Group Specific Substances"; and H. A. Barker, University of California, Berkeley, "Biochemical Studies With Bacteria." The symposium on the afternoon of June 23 will be on "Physical and Inorganic Chemistry," with George Cady, University of Washington, discussing "Fluorocarbons"; I. Perlman, University of California, Berkeley, "Nuclear Transformations at High Energies"; and Henry Eyring, University of Utah, "Kinetics of the Plastic Deformation of Solids." Those wishing to present papers at the June 22 (afternoon) and June 23 (morning) sessions should contact the chairman of the Section, M. Calvin, Department of Chemistry, Radiation Laboratory, University of California, Berkeley 4, California.

## Resolution on Civil Liberties

The Executive Committee, at a meeting on April 25, passed the following resolution:

The Executive Committee of the American Association for the Advancement of Science believes that in the interest of the national welfare it should protest against the treatment of Dr. E. U. Condon, director of the National Bureau of Standards, by the subcommittee of the House of Representatives Committee on Un-American Activities. The charges made against Dr. Condon were given wide publicity previous to the holding of any hearing.

The continuation of American scientific achievement for the purposes of both peace and war depends upon the freedom and peace of mind of our scientists. They have no right to ask for special privileges, but they certainly should have the rights accorded every citizen by the Constitution of the United States with its Bill of Rights and should be protected against treatment of the sort accorded Dr. Condon.

We believe that such action by any Congressional committee tends seriously to jeopardize the effectiveness of the entire program of scientific research of the United States Government.

## Request for Address Information

The AAAS membership office, 1515 Massachusetts Avenue, N. W., Washington 5, D. C., would appreciate information concerning present residences of the following Life Members, listed here with their last known addresses: Shigeo Yamanouchi, Department of Botany, University of Chicago; John Max Wulfing, Jr., Chi Psi Lodge, Brunswick, Maine; Seehorn Seneker, 187 Southern Methodist University, Dallas, Texas; Edward L. Miloslavich, Department of Legal Medicine, Royal University, Zagreb, Yugoslavia; Rev. J. D. Marmor, 12 East 115th Street, New York City; Fred I. Lackenbach, 908 Butler Building, San Francisco; Mary L. Jackson, 6842 Penn Avenue, Pittsburgh; George Iles, Hotel Chelsea, 222 West 23rd Street, New York City; Karl F. O. Haack, New York City, New York; A. W. Elliott, 562 West 113th Street, New York City; and Mrs. William Belknap, Oscawana on Hudson, New York.

# TECHNICAL PAPERS

## The Change in the Leucocytic Formula by the Leucocytosis-promoting Factor of Exudates in Experimental Leucemia

VALY MENKIN[1]

*Agnes Barr Chase Foundation for Cancer Research, Temple University School of Medicine, Philadelphia*[2]

The writer has demonstrated in numerous observations that injured cells liberate in exudates a factor capable of inducing a leucocytosis in animals (*2, 4, 6*). This factor likewise induces a hyperplasia of granulocytes in the bone marrow (*5*). The identification of the factor offers a reasonable explanation for the mechanism of leucocytosis with inflammation. The canine material is active on human beings (*9*), thus suggesting its possible clinical application. The factor, isolated at first as a pseudoglobulin (*4*), has recently been studied electrophoretically in a Tiselius apparatus and, as such, has been found to be distributed between the $\alpha_1$ and $\alpha_2$ globulins (*1*). The fact that it reinforces the leucocytosis when superimposed on an already existing inflammation suggests further clinical possibilities (*7*). Finally, aging the material has shown that the active group is a poly peptide probably attached to the pseudoglobulin mole cule (*8*).

In view of the fact that the leucocytosis-promoting factor (abbreviated as the LPF) induces a hyperplasi or growth of granulocytes in the bone marrow (*5*), it has been pointed out that it might be of interest to study the action of this material in experimental leucemia (*5*). This communication is a brief preliminary report of such observations on AK mice inoculated with a strain of chloroleucemia (1394), obtained through the kindness of Drs. Furth and Burchenal.

Leucemia was induced by the subcutaneous inoculation of leucemic material. In a few instances the development of the disease was hastened by the introduction of leucemic cells by the intravenous route. In one instance the disease was induced by intraperitoneal inoculation.

TABLE 1

EFFECT OF THE LEUCOCYTOSIS-PROMOTING FACTOR (LPF) ON THE DIFFERENTIAL LEUCOCYTE LEVEL

| Identification of leucemic mice | Number of subcutaneous injections of LPF (about 1–2 mg of LPF) | Initial differential count (%) | | Differential count a few days before animal's death (%) | | Length of survival of animals (days) |
|---|---|---|---|---|---|---|
| | | Polymorphonuclears | Mononuclears | Polymorphonuclears | Mononuclears | |
| F | 4 | 59 | 41 | 68 | 32 | 6 |
| G | 23 | 20 | 80 | 42 | 58 | 43 |
| H | 13 | 8 | 92 | 28 | 72 | 25 |
| I | 67 | 4 | 96 | 28 | 72 | 148 |
| J | 24 | 2 | 98 | 70 | 30 | 48 |
| K | 100 | 12 | 88 | 70 | 30 | 209 |
| S | 17 | 22 | 78 | 56 | 44 | 53 |
| O | 13 | 24 | 76 | 38 | 62 | 21 |
| V | 9 | 17 | 83 | 40 | 60 | 26 |
| X | 13 | 53 | 47 | 40 | 60 | 37 |
| $L_1$* | 14 | 4 | 96 | 82 | 18 | 37 |
| $M_1$* | 11 | 14 | 86 | 46 | 54 | 31 |
| 1–D* | 31 | 5 | 45 | 34 | 66 | 56 |
| $H_1$ | 39 | 22 | 78 | 48 | 52 | 62 |
| $J_1$ | 50 | 20 | 80 | 56 | 44 | 81 |
| Average | ... | .. | .. | .. | .. | 59 |

* Leucemia induced by the intravenous route; in others, disease induced by the subcutaneous route.

A few days to a few weeks later the LPF in doses of 1–2 mg in 0.2 cc of saline or water was injected subcutaneously in the experimental mice. The injection of the material was at first daily, but after several weeks the injections were spaced to occur about three times per week. The LPF was derived from canine exudates, as originally described (*6*). The scheme of extraction may be briefly tabulated as follows: exudates (usually alkaline) → 1/3 sat. $(NH_4)_2SO_4$ → centrifuge → dialyze supernatant for about 24 hrs when it usually is free of $SO_4^=$ → add sat. $(NH_4)_2SO_4$, 1:1 → let stand on

[1] The author's thanks are due Ruth Lewin for doing the absolute white blood cell counts on the mice used in this experiment.

[2] Aided also by a grant from the National Advisory Cancer Council.

for several days to settle down → decant or syphon off supernatant fluid → centrifuge precipitate → dialyze unsettled part of precipitate for about 24 hrs until free of $SO_4^=$ → LPF → lyophilize.

The results of all the experimental observations to date are collected in Table 1. It is clear that the predominance of mononuclear cells (lymphocytes, monocytes, and leucemic cells were all combined in one group), i.e. prior to the course of administration of LPF, is shifted very soon and persists until a few days prior to the death of the animal. In the great majority of cases the percentage of polymorphonuclears increases. This is not seen in control animals inoculated with leucemia but receiving no injection of the leucocytosis-promoting factor (Table 2). It may be reasoned that this shift in the differential formula may be referable to a mere discharge by the LPF of polymorphonuclear leucocytes from the bone marrow. This does not seem to be the case, for in a series of 10 mice inoculated with .05 cc of a saline suspension of liver material derived from a leucemic mouse, in turn inoculated with chloroleucemia 1394 into the skin, the injection of four successive doses

TABLE 2

CHANGE IN THE DIFFERENTIAL LEUCOCYTE FORMULA IN NONINJECTED LEUCEMIC MICE

| Identification of leucemic mice | Initial differential count (%) | | Differential count a few days before animal's death (%) | | Length of survival of animals (days) |
|---|---|---|---|---|---|
| | Polymorphonuclears | Mononuclears | Polymorphonuclears | Mononuclears | |
| T | 6 | 94 | 12 | 88 | 24 |
| L | 24 | 78 | 4 | 96 | 4 |
| B* | 28 | 72 | 4 | 96 | 26 (approximately) |
| S-D† | 42 | 58 | 38 | 62 | 25 |
| L | 48 | 52 | 38 | 62 | 48 |
| Average | .. | .. | .. | .. | 25 |

* Leucemia induced by intravenous route.

† Disease induced by intraperitoneal route; in others, disease induced by subcutaneous route.

of LPF over a period of several weeks scarcely increased the total leucocyte count (from an average basal count of 10,275 to an average of 12,650). As a rule, the shift in the differential formula occurs after two or three subcutaneous injections into AK mice of canine leucocytosis-promoting factor. The absolute leucocyte level in 10 leucemic mice of noninjected mice is likewise followed in the first few weeks by only a moderate rise in the number of circulating leucocytes (from an average basal level of 12,025 to an average level of 17,062). Yet in such animals the differential leucocytic picture does not show any increase in the percentage of polymorphonuclear leucocytes (cf. Tables 1 and 2). It was also observed that mouse leucemia is often accompanied in its earlier stage by a definite aleucemic picture. This had been pointed out to occur by Furth in his early studies on lymphomatosis of mice and lymphoid leucemia (*2*). It is merely suggestive that, although the range of variation is wide, the experimental animals injected with the LPF seem to survive for longer intervals than do the controls (cf. Tables 1 and 2). This phase of the work, however, will require further study on larger groups of animals before this becomes an established fact.

In view of these results on the apparent but not certain maturation of polymorphonuclear leucocytes in leucemic animals injected with the LPF, and in view of the fact that this substance can be injected into human beings innocuously (*9*), several children severely ill with acute leucemia were repeatedly treated intravenously with the LPF. In general, the doses were in the beginning rather small, and this may be a factor in the effect obtained. The doses ranged from 16 to about 100 mg or so. In brief, all the children succumbed of their disease. There was no change in the percentage of blast formation nor was there any sign of maturation. The only positive effect was the frequent drop in the total leucocyte level following the injection of the leucocytosis-promoting factor.[3] It is debatable whether or not this represents a reduction in the rate of growth of malignant cells. One also wonders whether human and mouse leucemia respond precisely in the same manner to a given substance. The two diseases, although similar in many respects, may also have differences. It would be of interest to pursue these studies with larger doses of the LPF and also in patients with chronic forms of myelogenous leucemia.

In conclusion, it seems as if repeated subcutaneous injections of the leucocytosis-promoting factor of inflammatory exudates, when repeatedly administered to experimental leucemic mice, induce a shift in the differential leucocytic formula, with a concomitant rise in the percentage of mature polymorphonuclear leucocytes occurring in the circulating blood.

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[3] In leucemic mice it has also been observed that the leucocytosis-promoting factor may tend at first to decrease only the absolute level of white cells in the circulating blood without causing a shift in the leucocytic formula. It is only with potent fractions of the material, repeatedly administered, that there is also a rise in the percentage of polymorphonuclear leucocytes.

# Loss of Contractility of the Uterus and Partial Atrophy of the Uterus and Ovaries in Albino Rats Fed Choline-deficient Diets[1]

MARGUERITE PEET[2] and MYRA M. SAMPSON

*Department of Zoology, Smith College*

The importance of choline as a dietary constituent has been recognized since the discovery that choline deficiency caused an accumulation of fat in the liver of rats fed diets low in casein and high in fat content (*2, 3*). It has also been demonstrated that such a deficiency causes a hemorrhagic condition of the kidneys (*6*) and of other organs (*4, 5*). In addition, it has been reported that dietary choline may be essential for biosynthesis of adequate amounts of acetylcholine (*9*), for normal contraction of skeletal muscle (*7, 8, 10*), and for normal contraction of cardiac muscle (*1*). The results obtained in the present investigation show that choline deficiency caused a complete loss of contractility of the uterus and partial atrophy of the uterus and ovaries in mature albino rats.

Two pregnant albino rats of the Wistar strain obtained from Carnsworth Farms were placed at parturition on a choline-deficient diet for 39 days; two others were placed on the same diet supplemented with choline. The

TABLE 1

FORMULA OF THE CHOLINE-DEFICIENT DIET

| | | |
|---|---|---|
| Casein (Labco vitamin free) extracted with alcohol | 10% | |
| Lard | 20% | |
| Salt mixture (Hubbell, Mendel, and Wakeman) | 4% | |
| Sucrose | 66% | |
| Thiamine chloride | 400 μ | (per 100 gm of diet) |
| Riboflavin | 200 μ | |
| Pyridoxin | 200 μ | |
| Calcium pantothenate | 1.5 mg | |
| Nicotinic acid | 2.5 mg | |
| Vitamin A | 80 I.U. | every second day in corn oil |
| Vitamin D | 1.5 I.U. | |
| Vitamin E (α-tocopherol) | 1.0 mg | |

litter of one died on the first day; those of the other three were living at the end of the experiment. Of the lactating rats, No. 1 received 30 mg, and No. 3 a supplement of 200 mg, of choline every second day. Rat No. 2 and the nonlactating rat, No. 4, were given no choline supplements. The choline-deficient diet employed, that of Hegstead (1941), is represented in Table 1. Because of considerable loss of weight within the first four days, an additional supplement of 1 gm of dried brewer's yeast and 5 gm of extracted casein was supplied every second day to all the rats.

Weekly records were kept of food intake and weight gain and of differences observed between rats with and without choline. At the termination of the experiment the adults and some members of the three litters were killed with ether and autopsied immediately.

The most marked difference noted prior to the termination of the experiment was the development of a yellow, oily condition of the hair of rats which received the choline supplement. This appeared within 14 days in the rat receiving the 200-mg supplement of choline and a few days later in her litter. In the rat receiving the 30-mg supplement a similar appearance was noted on the 27th day and shortly after in her litter. By the 36th day it was marked in both adults and their litters and was so extreme in those receiving the 200-mg supplement that skin of persons handling these rats became oily. The hair of the deficient rats remained normal and, on transfer to a stock diet, the hair of litters which had been fed the high fat diet supplemented with choline resumed its normal color and consistency. No other consistent differences were noted in adults or litters during the experiment.

At autopsy the outstanding differences between the rats fed diets with and without choline were the complete lack of contractility of the uterus and a partial atrophy of the uterus and ovaries in the choline-deficient rats. The uterus of each of the rats which received choline contracted as soon as it was exposed to air and on mechanical stimulation, whereas those of rats deprived of choline showed no contractility at any time, regardless of any stimulation. The horns of the uterus were small in diameter, greatly elongated, and pale in color; the ovaries were smaller in size and their ova negligible in the choline-deficient as compared with rats given choline. The dimensions of the uterus and of the ovaries are represented in Table 2.

TABLE 2

| Rat No. | Diet | Horn of uterus | | Ovary | |
|---|---|---|---|---|---|
| | | Length (mm) | Diam. (mm) | Length (mm) | Diam. (mm) |
| 1 | Adeq. | 23 | 3.5 | 5 | 4 |
| 2 | Def. | 27 | 2.0 | 3 | 3 |
| 3 | Adeq. | 24 | 3.0 | 5 | 4 |
| 4 | Def. | 37 | 3.0 | 4 | 4 |

In the deficient adults the liver was pale and glistened with fat, and the kidneys were obviously hemorrhagic. A similar condition was noted in the liver but not in the kidneys of members of their litters. No paralysis such as that reported by Sure (*10*) occurred in litters of rats fed on the choline-deficient diet.

The results indicate that choline deficiency in mature albino rats caused a loss of contractility of the uterus and a partial atrophy of the uterus and ovaries, in addition to accumulation of fat in the liver and hemorrhage in the kidneys characteristic of choline-deficient animals. Choline supplements prevented such abnormalities, facilitated the mobilization of fat from the liver, as indicated

[1] Smith College Zoology Publication No. 218.

[2] Data in this report are from a paper submitted by Marguerite Peet in partial fulfillment of the requirements for the degree of A.B. with honors.

the relatively low fat content of the latter, and led the elimination of excess fat by skin glands, as indicated by the oily condition of the skin in rats supplied with choline.


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## Calcium Deficiency in Serpentine Soils as Revealed by Adsorbent Technique


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The Conejo soil series near Morgan Hill, California, is derived from outwash material of a serpentine rock area. The soil is deep, and rich in clay. The pH of the surface is 7.2. Conejo clay contains about 5.5 milliequivalents of exchangeable calcium/100 gm of soil. In comparison with many productive soils, this value is not low.

Conejo soil was brought to Berkeley and placed in pots containing 1,600 gm of soil. In the check pots romaine lettuce made little growth. Additions of nitrogen, phosphorus, and potash increased plant growth significantly, seemingly supporting the idea of Gordon and Lipman (*1*) that serpentine soils are unproductive because of deficiencies in nitrate, phosphate, and potassium.

After two to four weeks the lettuce plants on the fertilized soil developed a rosette disease. The young, inner leaves curled and became extremely stunted. Intense light enhanced these symptoms. Rosette, in various degrees, was also observed on serpentine soils of the Henecke and Venado series and on Maxwell and Dublin soils.

Following a suggestion by Robinson, *et al.* (*4*) that chromium and nickel, and perhaps cobalt, are the dominant causes of infertility in serpentine soils, normal lettuce plants grown on a productive soil and abnormal plants (rosette) from Conejo soil were analyzed spectrographically by A. P. Vanselow at the University of California Citrus Experiment Station. No consistent differences in Cr, Ni, and Co content could be observed. Adding these elements to good Yolo soil or spraying normal lettuce leaves with the soluble salts did not produce rosette disease.

After having initiated a great variety of treatments, we observed that gypsum and, to some extent, lime would combat the disease. Since serpentine soils are notoriously high in magnesium, these observations seemed to agree with Loew's (*2*) old theory of the Ca-Mg-proportions.

The question whether rosette disease is conditioned by magnesium excess or calcium deficiency, either absolute or relative, was elucidated with the aid of adsorbent technique, using cation amberlites as ionic carriers. Amberlites saturated with Ca, Mg, Sr, and K were added to fertilized Conejo soils and Yolo soils, the latter being a productive soil. The results were as follows:

(1) Ca-amberlite added to Yolo soil did not retard the excellent growth of the plants. Apparently the amberlite anion itself, in the amounts used, had no injurious effect on lettuce plants. Ca-amberlite added to Conejo soil overcame the disease and produced normal plants, comparable in weight and appearance with the plants grown on Yolo soil.

(2) Mg-amberlite added to Yolo soil produced characteristic rosette disease symptoms. When Mg-amberlite was added to Conejo soil, the extent of the disease was enhanced.

Experiments 1 and 2 rule out Cr, Ni, and Co as disease-producing agents.

(3) K-amberlite incorporated in Yolo soil produced lettuce rosette, and it emphasized the disease in Conejo soil. This experiment rules out magnesium as the primary factor. In the case of Yolo soil, it also eliminates the absolute level of exchangeable calcium (Moser's hypothesis, *3*) as the causal element.

Experiments 1, 2, and 3 suggest that the degree of saturation of exchangeable calcium is a prime contributing factor in the origin of lettuce rosette.

(4) Sr-amberlite added to Yolo soil in the same amount as Mg- and K-amberlite did not produce the disease. In Conejo soil it improved plant growth slightly but did not appreciably reduce the disease. The behavior of Sr-amberlite suggests a partial substitution of Sr for Ca in the growth of romaine lettuce.

While these experiments established the cause of rosette disease with the aid of soil studies and adsorbed ion technique, the crucial aspects could also be demonstrated with water culture experiments. Thus, the disease was produced in nutrient solutions as a result of calcium deficiency, in absence of significant amounts of cobalt, chromium, and nickel.

Similar results have been obtained with barley plants, which exhibit their own specific symptoms. A more detailed report will be published elsewhere.


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# IN THE LABORATORY

## Radioautograph Technique With $C^{14}$

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Over the course of the past 6 months a method has been developed for taking radioautographs with $C^{14}$ which provides the intimate contact required between tissue section and film and makes it possible to develop the film and stain the section while they are in contact. With reasonable care the developer can be kept from affecting the tissue, and the stain can be kept out of the emulsion. Thus, normal histochemical procedures can be used on a tissue section either before or after the radioautograph has been taken. It may be noted that the present technique is not merely another histochemical method; rather, it now makes possible the use of most histochemical methods in conjunction with radioautographs. Thus, for example, if prestained tissue is used, the radioactivity can be precisely located by selective leaching of the various biochemical fractions.

Although similar methods for making radioautographs with β-emitting isotopes have been proposed by Evans (*2*) and Pelc (*4*), following the work described by Gross and Leblond (*3*), none of these methods satisfies the desirable criteria of independence of staining and development. In Evans' method, the tissue shields the exposed portion of the film from the developer; and the emulsion, as well as the tissue, is stained. In Pelc's method the film is developed uniformly, but no method of staining has been used.[3]

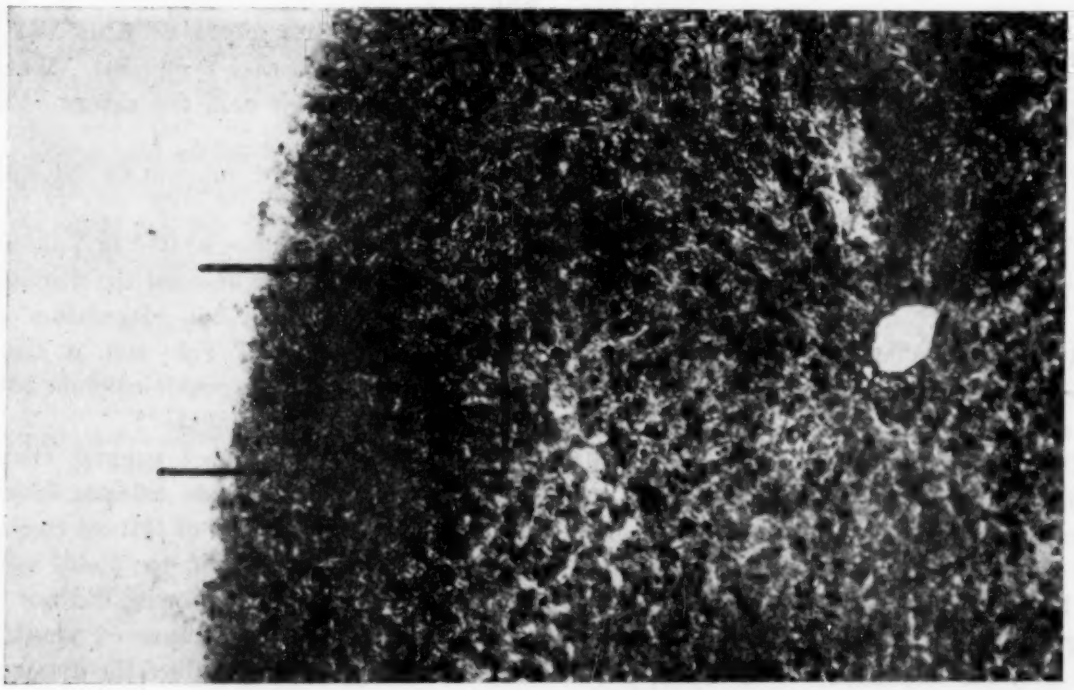

Fig. 1. Rabbit liver. A 10-μ paraffin section (×110), prestained with hematoxylin and eosin; Type M stripping film; exposure, 25 days.

Deane, Nesbett, Buchanan, and Hastings (*J. cell. comp. Physiol.*, 1947, **30**, 255) have shown that the glycogen is deposited at the periphery of the section under experimental conditions similar to those described here. The radioactive glycogen at the edge of the tissue shows up as the black band at the left edge of the tissue. The individual silver grains can be seen best by careful examination of the background fog to the left of the tissue. The large black spots within the tissue section are stained nuclei, and the gray background is cellular tissue. The differentiation between tissue and autograph is clear, of course, in the microscope, where the colored stains show up.

In brief, the present method requires stripping film, a 10-μ emulsion which, with its 7-μ base, can be stripped from a heavy supporting film. A tissue section is mounted on a glass slide, the stripping film is cemented, base side down, onto the tissue, and the radioautograph is made. After development, the film and tissue slice are

[1] Now returned to the Department of Pathology, University of Edinburgh, Scotland. (Requests for reprints should be addressed to the Biophysical Laboratory.)

[2] This work has been supported in part by the Office of Naval Research. One of us (A. M. M.) carried out the research while holding a Rockefeller Fellowship in Pathology.

[3] Since this article was submitted for publication, Leblond, Percival, and Gross (*Proc. Soc. exp. Biol. Med.*, 1948, **67**, 74) have proposed the use of prestained tissue which is coated first with celloidin and then with fluid photographic emulsion.

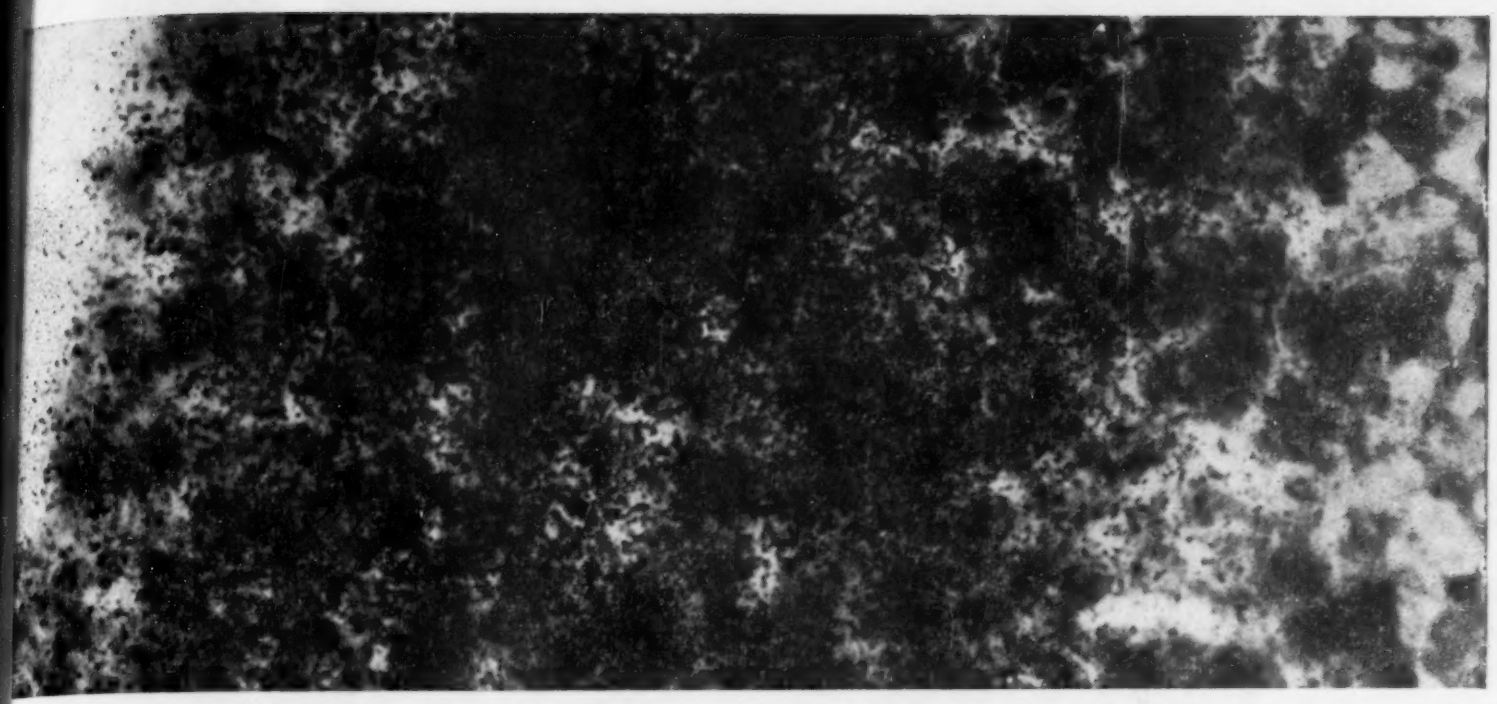

FIG. 2. High power of portion of outlined section of Fig. 1 (magnification, ×600).
For this photograph the silver granules are in focus. Since the granules are separated from the tissue section by 7μ or more, it is not possible at this magnification to bring both section and autograph into focus simultaneously. Nevertheless, the large, blurred, black nuclei may be distinguished from the particulate silver. In the section shown, normal vacuolated liver cells without $C^{14}$ are seen on the right; in the middle is the tissue with the active carbon; and to the left is the stripping film itself with minimal fog.

removed together from the slide and cemented, this time emulsion side down, onto another glass slide. With the tissue now uppermost, the film base protects the emulsion from stain.

Since the primary purpose of the investigation was to work out a satisfactory technique for making radioautographs with $C^{14}$, it was first necessary to prepare a tissue slice with enough activity to enable us to take autographs in a reasonable period of time. For this purpose, slices of rabbit liver from an animal starved for 48 hrs were incubated *in vitro* with $NaHC^{14}O_3$, in the presence of a pyruvate substrate. This method is a modification of that previously described (*1*). After 2 hrs of incubation, the slices were removed from the medium, and fixed

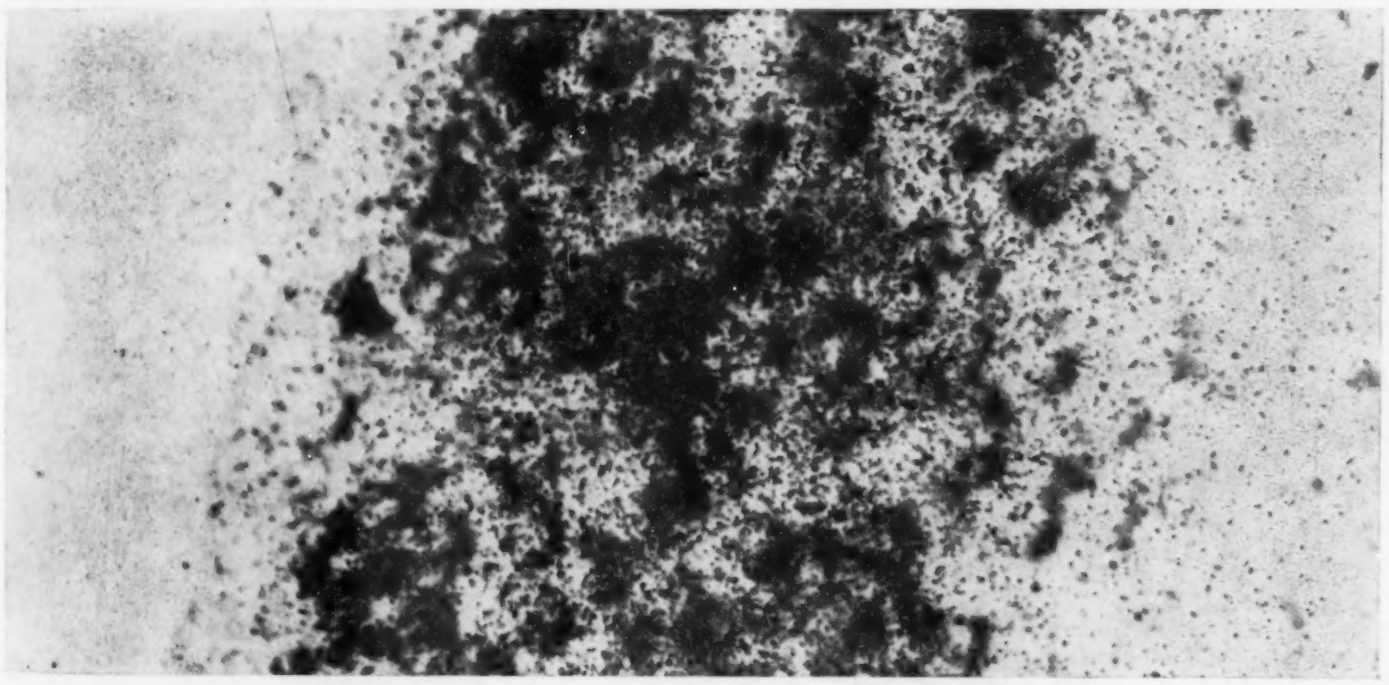

FIG. 3. Liver section (×400), prestained by Feulgen Bauer method for glycogen.
The cloudy black effect of the histochemical staining for glycogen may be seen superimposed by the particulate black of the photographic image and effectively synchronizing with it. From left to right on the film may be seen the stripping film with mild fogging effect, image synchronizing with cells, and normal liver counterstained with basic fuchsin.

in Rossman's fluid. Sections were cut at 2-, 5-, and 10-μ thickness.[4]

Early experiments indicated that stripping film would give us the intimate contact necessary for high resolution, but the stripping film available commercially was too slow to enable us to work with our tissue sections. Burt H. Carroll, of the Eastman Kodak Company, was kind enough to supply us with stripping film coated with Eastman Type M X-ray emulsion. Of the emulsions tried, Type M gave the highest resolution compatible with the high sensitivity that was needed. Agfa Reprolith stripping film, a commercial product, is very satisfactory when tissue containing large amounts of radioactivity is used. Details of experiments with other emulsions and elements, along with a full description of our technique, will be described in a later publication.

The method is as follows: Paraffin is removed from the section with xylol, the section then being washed in absolute alcohol and allowed to dry. Sufficient 1% celloidin to cover the section is added with a Wright pipette.[5] The stripping film is removed from its base and applied, emulsion side uppermost, over the liquid celloidin-covered tissue section. The film is then pressed over the section until the celloidin is dry. A piece of fine, hard filter paper protects the emulsion from direct contact with the fingers, and great care is taken that the displaced celloidin does not run over onto the emulsion. The filter paper is removed, the emulsion is covered with a guard slide, and the sandwich wrapped round with Scotch tape and exposed under 12.5 lbs/in$^2$ of pressure. All the operations of development, fixing, and washing are done in a test tube 1″ in diameter. The film is never removed from the test tube; the solutions alone are changed. Distilled water is used in all operations, including washing, and all precautions necessary for fine development are observed. After the final washing, if the film with its firmly attached section is not detached from the glass slide, gentle traction will make the removal complete. The film, now emulsion side down, is attached to another glass slide with Kodalith stripping cement, allowed to dry, and treated like an ordinary section. The thin film base and the cement protect the emulsion from stain.

Figs. 1, 2, and 3 show examples of radioautographs taken with this technique.

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[4] We are grateful to F. M. Sinex and Miss Frances Nesbett, of the Department of Biological Chemistry, for preparing the liver slices and carrying out the incubation, and to E. W. Dempsey, of the Department of Anatomy, who has occasionally assisted in preparing the tissue sections.


[5] Since this article was submitted, we have observed some sections in which the celloidin apparently caused a uniform dense fog. Experiments are under way to determine the exact cause of this fog.

## A Method for Making Small Rubber Articles for Laboratory Use


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By the simple method described here one can make reliable, elastic, thin-walled rubber balloons, of various shapes, for sensitive kymograph recording of gastric and doudenal movements, etc., as well as thin-walled rubber tubing of short lengths and various shapes.

The apparatus and chemicals required are: 60% Latex,[1] molds, wide-mouthed bottles, glass cylinders, rack to hold molds, sulfur chloride solution (SCL Merck), and a drying oven.

The molds are made of glass blown to the shape and size desired, with a stem for holding them. For making the balloons, a sufficient amount of Latex solution is poured from the stock can into a suitable short, cork-stoppered, wide-mouthed bottle. For the rubber tubing, a tall glass cylinder fitted with a cork stopper is required. The clean glass mold is dipped three times into the Latex solution, care being taken to avoid the creation of air bubbles. The mold should not be allowed to touch the container or any object after dipping. The surplus solution is then drained off for a moment or two, after which the mold is revolved slowly by hand until an even layer of the Latex is attained. It is then placed in a drying oven maintained at 60–80° C. The oven can be improvised by utilizing a wooden or tin box, about 18″ square, containing a 150-watt electric lamp. When first dipped, the Latex solution is an opaque milky white. When dry the color fades and the Latex becomes transparent. At this stage, it is ready for vulcanizing. A few drops of sulfur chloride are poured into a wide-mouthed bottle (for the balloons) or a cylinder (for the tubing) which is immediately corked to contain the vapor until one is ready to insert the mold. The stem of the mold is securely inserted into the hole of a second cork which fits the bottle or cylinder, and thus the mold may be suspended in the bottle or cylinder containing the vulcanizing fluid (SCL). The mold must be so suspended that it is exposed only to the vapor. One minute or more will suffice to vulcanize a mold coated as described above. If a heavier coating of Latex is applied to the mold, by repeated dipping after the first coat has dried, a slightly longer time is required for vulcanization. As soon as the mold is removed, the vulcanizing bottle, or cylinder should be firmly stoppered again to preserve its contents. The vulcanized article is now dipped in talc and gently rolled off the mold. It should be soft and elastic so that, when stretched, it returns to its original shape. If the mold is left too long in the vulcanizing vapor, it will stiffen and become brittle. A little practice in timing will bring good results.

[1] Obtainable from General Latex & Chemical Corporation, 600 Main Street, Cambridge, Massachusetts.